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Agriculture and Chemistry

IT is not necessary to write down a list of the many chemical products that are derived from vegetation to become aware of the close relationship that exists between agriculture and chemistry. "Agriculture," wrote Gibbon, "is the foundation of manufactures, since the productions of nature are the materials of art." Science has its part to play in agriculture, as witness the fertiliser and soil chemistry, and science is doing its best to take away the truth of the old Latin proverb that "Hope sustains the Husbandman."

It is not generally recognised that deserts are made by man. The United States is already in dire difficulties because faulty methods of cultivation in the days of the pioneers have caused irreparable damage by soil erosion, which have given rise to the now classic, but tragic, story of the agriculturalist visiting a near-by town who having signified his intention of returning home saw a duststorm approaching. "No need to go now folks," he said, "here's my farm coming past." The hinterland from which the wealth of Carthage was derived was one of the most fertile regions of the Roman world. To-day the Sahara has taken its place—and it is still growing. An inch of soil may take several thousands of years to form, for it originates from the gradual weathering of rock. It is protected from the erosive action of wind and water by a covering of vegetation, which also enables rain-water to sink in and to make it fertile. If the vegetation be removed the soil is washed or blown away; what remains becomes arid and thus unable to support its normal amount of vegetation and denudation is accelerated. Mankind, by faulty methods of agriculture, can destroy the ancient work of nature in a very few years. We are facing the same situation in Africa. The importance of African products to chemical industry is considerable. We have taught the natives how to cultivate the land, and how to breed more and more cattle, with the result that the cattle are too many by far for the carrying power of the land and too intensive cultivation of the African soil is assisting the intensive feeding of cattle to accelerate the work of denudation. Deforestation, extension of cultivation and over-grazing are making all Africa into a desert. This is one of the most important problems that the British Government has to face, and it is complicated by the difficulty of making the native understand that his recently increased prosperity must be curbed in his own ultimate interests. Among the suggestions that are under consideration and that would be of direct interest to chemists is the establishment of blood and bone fertiliser factories which would buy up a certain proportion of stock in the area covered.

Whilst upon the subject of fertilisers attention may be directed to Sir Albert Howard's method in India

of systematically using all organic waste together with animal excreta to make a compost which is said to have been found superior to the farmyard manure of old, now no longer produced in sufficient quantity due to the displacement of the horse by the motor. Professor H. E. Armstrong has characterised this method as a great advance in farming. At the same time he has also pointed out the value of weeds in agriculture, and reading his comments (*Chemistry and Industry*, June 12) in the light of the world's soil erosion difficulties, one wonders whether the cultivation of a proportion of weeds may not be one solution of the difficulty. The dandelion and stinging nettle and many other "weeds" are good for food; we know but little about the effect of weeds on agricultural products. Is not weed research a yet untouched branch of agricultural chemistry?

Sir Harold Hartley, delivering the Mather Lecture the other day, remarked that though the chemist could synthesise many of the most complex natural substances in the laboratory, as a general rule nature is a cheaper producer than the factory. That is perhaps the purely selfish outlook of the chemist towards the problems of soil erosion—if large areas become desert he will be deprived of (a) markets, and (b) of a cheap source of supply of raw materials. The chemist, and the scientist generally, however, has more to do with the problem than that. Sir Harold mentioned that America has 1,600 industrial laboratories employing 35,000 specialists at an annual cost of £40,000,000, and that among the long-term problems to be faced agriculture was among the most serious. The problem is to widen the use of existing farm products, and to find new crops to replace such imported products as soybean, tung oil and starch. This problem has arisen because of soil erosion, of loss of fertility of land used continuously for similar crops, of the large extension of arable land during the war, of the substitution of the tractor for the horse with its reactions on the consumption of foodstuffs, and on the economics of farming. Amongst the steps already taken has been the construction of a large factory by Mr. Henry Ford for producing plastics from soybean-meal and formaldehyde.

Sir Harold Hartley gave some striking figures to illustrate the industrial importance of agriculture. A million Ford cars require: 89,000,000 lb. of cotton, 500,000 bushels of maize for rubber substitutes, butyl alcohol and solvents, 2,400,000 gallons of linseed oil, 2,500,000 gallons of molasses, 3,200,000 lb. of wool, 1,500,000 sq. ft. of leather, 20,000 hogs to supply 1,000,000 lb. of lard, oleic acid, and bristles, 350,000 lb. of mohair and 2,000,000 lb. of soybean oil for the enamel.

Notes and Comments

Aluminium and Silicosis

APAPER lately presented to the Academy of Medicine in Toronto contains what is described by that body as "a most outstanding contribution to silicosis research." On prior occasions we have pointed out the widespread toll of human life that has in the past been taken by silicosis, and at the time of the Chemical Engineering Congress last year we referred to the heavy mortality in South Africa, which was only diminished by insisting on all entrants to the mines undergoing a medical examination, those passed for mine employment being of the highest physique. It was then noted that two discoveries had been made which now permitted of the employment of men of lower physical grades. One of these was that silicosis was due to mica and not to silica, and the other that the deadliness of the dust was greatly diminished if its concentration were kept below a certain limiting figure. The conclusion regarding mica is not generally accepted, we understand, and quartz is still regarded medically as the prime agent in the causation of the disease. It is more probable that the control of the dust concentration has hitherto been the principal factor in silicosis prevention in the less physically fit. The Canadian discovery is based on the theory that quartz dust is dissolved in the lungs by some of the vital fluids there present, and produces degeneration of the organs. If, however, aluminium dust is mixed with the siliceous dust, it is claimed that the solubility of the quartz is reduced, and the formation of nodules in the lungs is prevented.

Chemistry and Sport

THE playing field and the winter sports ground are becoming chemically invaded, and the chemist apparently can no longer leave his science behind when he seeks occupation for his leisure hours. The study of soil chemistry in relation to golf greens has already been in progress some years, and next month the members of the Society of Chemical Industry will visit a research station at Bingley whose principal object is to investigate the conditions giving the most satisfactory turf. A writer in the "Chemical Practitioner" records that in America it has been found desirable to apply dyes to the grass of golf greens in order that they may retain their colour throughout the autumn and winter, instead of turning a rusty brown shade. Recently a crowd of 100,000 watched a football match at Philadelphia played on a dyed field. In the preparation of dance floor powders to make surfaces sufficiently smooth and slippery for treading the light fantastic, some knowledge of materials is needed. A recent patent to a Dorset inventor covers the idea of incorporating a small proportion of dyed or stained wax into the composition in order that the powder may be invisible on the floor. It will be a long time before it becomes necessary to install a laboratory and a chemist at Wimbledon, but even so, there are times when a chemist's knowledge is useful as far as racquets are concerned. Here is a new realm for research where energetic investigators might discover how to win the Davis Cup by fair means or chemical. In Switzerland it is the practice to treat the undersides of skis with waxes, each designed for a

certain condition of snow. Of what are these preparations composed? Here the chemist's curiosity asserts itself again, but there is little knowledge to be gained from chemistry books for snow and skis are not mentioned in most textbooks. It appears, however, that some German chemist has studied this somewhat attractive subject of research, and has found that a mixture of polymerised iso-butylene, bleached montan wax and tallow may be applied to skis.

Oil Industry Achievements

THE beneficial results of the increasing application of science to industry are probably nowhere more evident than in the oil industry, which is affected at both ends of its activities—production and consumption. As the result of exploratory drilling, the Anglo-Iranian Oil Co., as Lord Cadman told the stockholders on Monday, is developing two important new fields. At the same time new processes and different methods of manufacture have had to be evolved to meet the changes that have taken place in the motor car industry. Motor spirit that was a first-class product a few years ago has to be "reformed" to-day to meet current standards of quality, yet the complex product of to-day is appreciably cheaper than the simpler pre-war product. The company's fleet of 84 vessels—soon to be increased to 100—has involved the expenditure during the past twenty years in the purchase of oil tankers of about £20,000,000. The oil industry has also given help to other branches of British industry in the manufacture of oilfield equipment, in which large quantities of steel are employed and in the making of which, of course, much coal is used. Lord Cadman is of the opinion that the prosperous conditions that prevailed in the oil industry last year will continue.

Too Much Secrecy

MANY members of the chemical industry will agree with the view expressed by Dr. G. F. New, in his recent presidential address to the Oil and Colour Chemists' Association, that there is an unnecessary measure of reluctance to release for general discussion information previously regarded as confidential. The real value of membership of such an organisation as that over which Dr. New presides lies in the widening of knowledge by means of free interchange of information in the discussion room, and the greater the freedom of expression on the part of individual members, the greater will be the general acquisition of knowledge. In deprecating the fear on the part of certain employers that through open discussion their employees may give away more than receive we are not unmindful of the high commercial value of secrecy, but we have a shrewd suspicion that if all the so-called secrets so jealously guarded to-day were pooled it would be discovered that a very high percentage of them were not secrets at all. We do not know exactly how the matter could be tested, but it seems to us that it should not be beyond the wit of a well organised association to institute a kind of clearing house in which those items of information which are not secrets could be sifted from those which it is in the interests of the firms concerned to withhold from circulation.

The National Physical Laboratory

Annual Inspection Day at Teddington

ON the occasion of the annual inspection of the National Physical Laboratory on Tuesday some 2,000 scientists from all parts of Great Britain met at Teddington to review the work of the Laboratory and the advances made during the year. The visitors were received by Sir William Bragg, O.M., president of the Royal Society and chairman of the General Board, Lord Rayleigh, chairman of the executive committee, and Sir Frank Smith, director of the Laboratory and secretary of the Department of Scientific and Industrial Research. Special exhibits demonstrating the work were staged in the departments, and the laboratory was entirely thrown open to the visitors.

In the electricity department there was a demonstration of the prevention of fire risk in dry cleaning plants. It is well known that electricity is generated when two substances are rubbed together, and if the materials are non-conducting the charges may accumulate until a spark occurs. The "white spirit" or benzene used in "dry-cleaning" are non-conducting liquids, but experiments carried out at the Laboratory have shown that they may be made conducting by the addition of suitable soaps, thus removing the danger of explosion due to sparking. A demonstration was given of the fact that these soaps prevent the formation of electrostatic charges. A cotton belt running between pulleys is made to generate a charge by friction. About 5,000 volts is easily obtained, but this immediately falls to zero when the soap solution is added to the bath in which the belt runs.

Spectrophotometry, whether it be the determination of the spectral transmission curve of a coloured glass or solution, or finding the sensitivity curve of a photocell or other device for the measurement of light, is always a tedious and time-absorbing process. The use of photo-electric methods can, however, considerably shorten the work and correspondingly reduce the fatigue to the observer. A new form of photo-electric spectrophotometer has recently been developed at the Laboratory and was exhibited.

Corrosion Fatigue

The study of the fatigue of metals under corrosive conditions has thrown much light on the causes of many failures which were previously unexplainable. The researches carried out in the engineering department have shown that the fatigue resistance of some metals is considerably reduced even by contact with the atmosphere; thus, comparing the resistance in air with that in a vacuum, lead has only half the resistance, brass about 80 per cent., copper about 90 per cent. and mild steel about 95 per cent., while specimens of cupronickel and a magnesium alloy show no change. The research also showed that the active agent causing this effect was oxygen in the presence of water vapour. When tests are carried out using a salt spray as the corrosive agent, it is found that the reduction in resistance of steels other than stainless steels is very great; a steel capable of withstanding an alternating tension and compression of 25 tons per sq. inch was found to have its resistance reduced to about one-tenth of this value under the salt spray conditions. An investigation has also been made into the possibilities of using protective coatings on steels which are normally subject to this corrosive attack; some of these coatings have given almost complete protection. The information obtained from the research provides much useful data for the designer.

Lubrication

The subject of lubrication of bearings and machine parts is one which is increasing in importance in these days of power development and high efficiencies. Much study has been given to the subject at the Laboratory, but there are still many features which are obscure. Knowledge as to why one lubricant is better than another under a given set of conditions is still

limited. In addition, there are many factors involved in practice which react on one another (*e.g.*, the quality of the lubricant, and the form and mode of relative movement of the lubricated parts), which renders the practical problem one of extreme difficulty. Researches are being carried out to determine as far as possible the effect of each factor separately: thus tests are being carried out with shafts under continuous rotation, in which case a fluid film is formed between the shaft and bearing surface; and also with oscillating bearings in which the fluid film is either not formed or is not maintained continuously. In another case steel balls, covered with the lubricant, are caused to rotate against each other whilst under pressure, so that the pressure is highly concentrated, as in gears. In all these tests the temperatures and pressures are under control and can be carried over a wide range, and in the bearing tests the wear of the bearing and its change of shape can be measured. One important feature of an oil is the temperature at which it allows a bearing to seize under a given set of conditions of load, speed, and clearance, and this has been found to be seriously affected when a small quantity of water is mixed with the oil; a reduction of seizing temperature from 200° C. to 140° C. was obtained with only 0.05 per cent. of water, and this also resulted in an increase of 40 per cent. in the friction.

The Iron-Carbon Alloys

Since the alloys of iron with carbon form the basis of nearly all steels, it is important to know the melting, freezing and transformation temperatures of the pure alloys, free from the other elements which occur in commercial steels. Since the measurements of Carpenter and Keeling, carried out at the Laboratory and published in 1904, it has been found possible to prepare iron of higher purity, whilst a further transformation, not then known, has been discovered. A revision of this alloy system was found to be desirable, and has now been completed so far as the behaviour of alloys containing up to 1 per cent. of carbon is concerned, with the purest available materials and with modern precautions to avoid contamination. The results of this thorough study of these alloys were shown in the form of a diagram displayed in the metallurgy department.

Although the quantity of oxygen in a commercial steel is very minute, it has important effects on the properties of the metal. The Laboratory has been engaged for some time on a study of the oxygen question, and has devised special apparatus for the purpose. The total oxygen is determined by melting the steel in a graphite crucible and analysing the gases given off. It is also necessary to know how much of this oxygen is combined with other elements in the non-metallic inclusions in the steel. For this purpose samples are dissolved in a solution of iodine, air and substances containing oxygen being excluded, and the insoluble residue, amounting only to a few milligrammes, is analysed by microchemical methods. Several laboratories are now co-operating in this work with the object of arriving at standard methods of analysis.

Permeability of Wood by Gases

Experiments have been made, at the request of the Forest Products Research Laboratory, on the diffusion of gases through wood. The apparatus constructed allows tests to be made at constant temperature, with air and gas of constant relative humidity in contact with the two surfaces of a disc of wood. The pressure is the same on both sides, and the measurements are made either by observing the concentration of gas diffusing into a steady stream of air or by noting the rate of rise of the concentration in a fixed volume of air. The rates of diffusion of hydrogen across the grain of various woods have been found to vary by as much as 1 to 2,500, the lowest being given by oak heartwood, the highest by pine sap-

wood. There are significant differences between the rates of diffusion through radial and tangential sections of wood: the rates of diffusion along the grain are very much higher.

Magnesium alloys, being lighter than those of aluminium, are of importance in aircraft. Efforts are constantly being made to increase the strength of these alloys by improving the method of forging, and a demonstration was given of forging certain new alloys in a heated press under exactly controlled conditions. This method has been found to effect a considerable increase in the strength of the alloys.

In problems which arise in the manufacture of steel, including the processes of annealing and normalising, the heat evolutions at the transformation points are of importance.

These are now being studied in the physics department at the Laboratory by adiabatic calorimetry carried out at the temperature of the transformation itself. A heater is inserted within the ingot, whilst a jacket surrounding it is heated by a circuit which can be separately controlled. The whole apparatus is in a vacuum. Thus, when the heater within the ingot is in operation, if the jacket is maintained always at the temperature of the ingot, heat loss from the latter is suppressed. The energy input to the heater is then equal to the product of the temperature rise of the ingot and its specific heat (when there is no transformation in the range considered), or to the heat of transformation (when the experiments are carried out in the temperature range where this occurs).

Plasticizers

By W. D. SCOTT, A.R.C.S., D.I.C., Ph.D., of Monsanto Chemicals, Ltd.

A PLASTICIZER is a solvent for resinous materials which increases their degree of plasticity, or, in more general terms, their ability to deform inelastically. Cellulose esters and practically all resins, both synthetic and natural, have a brittleness that increases with age. To counteract this characteristic, as well as to give workability and flexibility, and to overcome the shrinking that causes cracking and shattering, plasticizers are added.

Generally, they are high-boiling substances which must have a negligible volatility at the temperatures of application and of utilisation of the resultant composition. Slow evaporation from a lacquer film will naturally lead to the condition of the film which the addition of the plasticizer sets out to avoid. During moulding, too, evolution of volatile matter causing bubbling and blistering, would be fatal to the finished moulding. Care must be taken, therefore, by the manufacturer of plasticizers to prepare a material preferably with a narrow boiling range and certainly without volatile impurities. The user of plasticizers must also be careful to select a material suitable for his moulding compositions or lacquer formulations, having particular regard to the volatility of the plasticizer as well as its compatibility with the ingredients of his resinous composition.

Growth of the Lacquer and Plastics Industries

Plasticizers came into particular prominence with the development of pyroxylin and the subsequent growth of the lacquer and moulded synthetic products industries. Camphor was the first satisfactory one, and it was its use with nitrocellulose that made celluloid and moulded pyroxylin articles possible. On account of the fire hazard attendant upon the use of articles made of nitrocellulose, a fire retarder was necessary and tricresyl phosphate came to play that rôle. In spite of numberless attempts to produce other compounds for the purpose, tricresyl phosphate still retains its place, although with improvements in nitrocellulose stabilisation it is not as essential in most compositions as formerly.

After the world war the availability of large stocks of butyl alcohol and a process for making phthalic anhydride cheaply opened the way for dibutyl phthalate as a component of the new nitrocellulose lacquers just becoming important. The combination of tricresyl phosphate and dibutyl phthalate was quite satisfactory until a host of new moulding and coating materials, composed largely of synthetic resins, were developed and requirements became much more exacting. These compositions required other plasticizers, or, to be more exact, properties not possessed by the old plasticizers became essentials. Extreme lack of colour, light stability, non-toxicity, water resistance, grease resistance, greater compatibility with special resins, gloss, smoothness of working, flexibility at low temperatures, non-softening at high temperatures, stability toward acids and alkalis, and other properties were demanded.

Cellulose acetate came actively into the plastic field and re-

quired entirely new plasticizers because, while most of the compounds proposed were compatible with nitrocellulose, very few were sufficiently so with acetate. Thus, for tricresyl phosphate, which is not at all compatible with acetate, must be substituted triphenyl phosphate, which has a good compatibility. Dibutyl phthalate is not compatible in amounts sufficient to give the desired properties, and therefore dimethyl phthalate and diethyl phthalate, in spite of relatively high evaporation rates, were used. In this country diamyl phthalate is finding an increased application as a nitro-cellulose plasticizer and in the near future there is likely to be a demand for diphenyl phthalate which incorporated in nitrocellulose lacquers produces hard coatings that have excellent gloss retention and weather resistance.

Need for Wide Range of Products

The exacting requirements of plasticizers for particular applications necessitates a wide range of products from which the manufacturer of mouldings and resinous coatings can choose the plasticizer most suited to his essential need. The phthalic and phosphoric esters are mainly employed in cellulose ester compositions, but exceptional properties, not imparted by these products, may be required. The phthalyl glycolates (santicizers) give particularly interesting results with nitrocellulose; butyl phthalyl butyl glycolate (santicizer B.16); for instance, probably embodies more desirable properties than any other nitrocellulose plasticizer, fire-retarding action being about the only property it does not have. This type of product can also be recommended for use with alkyd, phenolic, polystyrol and vinyl resins, and for chlorinated rubber. For urea-formaldehyde resins, protein compounds and shellac, the toluene sulphonamides (santicizers 8 and 9) are particularly suitable.

Besides the general ester class so far considered, there are other organic materials which may be introduced into a resinous composition for the purpose of incorporating some special property on the resultant film or resin. These may be of the resin class themselves, but as solvents which increase the degree of plasticity of the resultant composition they may be classed as plasticizers. Chlorinated diphenyls (aroclers), which act as fire retarding agents in cellulose nitrate lacquers, and sulphonamide-formaldehyde resins (santolites), which increase the retentivity of cellulose acetate for other plasticizers and tend to prevent separation and exudation, may be cited as examples.

Our knowledge of the function and behaviour of plasticizers in use is necessarily at the present time of a very empirical nature. When a new material is produced the manufacturer may examine the potentialities of his product with regard to its solubility in organic solvents, its compatibility with oils and resins, its retentivity, light-fastness, and toxicity, but the ultimate success as a plasticizer can only be indicated by its behaviour in use.

Some Notes on Solvent Recovery

By S. REGINALD PRICE

TO write of recent developments in the practical recovery of solvents from their vapour form, is to write of the progress in the application of activated carbon to this purpose. As I have been associated for some years with a group engaged in development, manufacture and application of all grades of activated carbon, namely, the Carbonisation et Charbons Actifs, or, more briefly, "Acticarbone," I may be forgiven if I treat the matter largely from the point of view of developments in this group. Moreover, this will, I think, give a good general view, as the company mentioned is equipped with large research and technical laboratories, expert staffs for the study and development of the properties and applications of activated carbon, has large manufacturing works for producing carbon of all grades, and a wide accumulated knowledge of recovery and rectification.

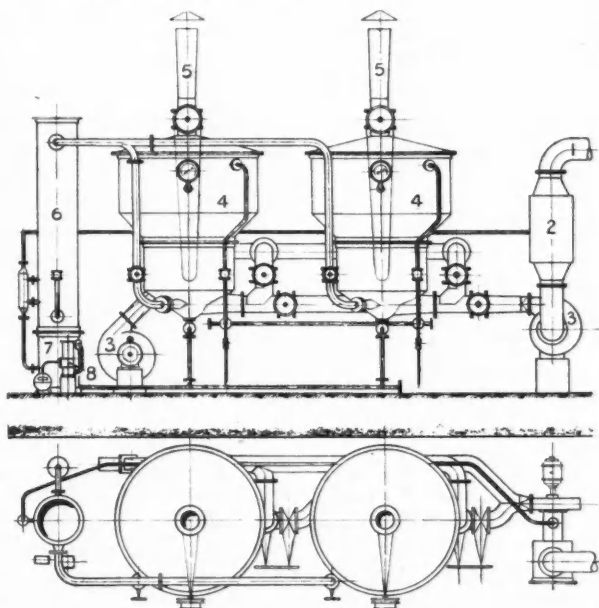
General Principle of the Process

The general principle of the process of absorption and recovery of vapours by means of activated carbon is now fairly widely known, and it may be said that the process is accepted as standard practice where solvent vapours are to be recovered. For the sake, however, of clarity in the later discussion, a brief recapitulation of the process will be given.

Activated carbon of a type and structure suitable for absorption in the vapour phase, has the property of carrying out an almost total removal of the solvent vapour from air, even at very low concentration, and this process continues till the carbon is saturated. Naturally, the saturation value varies according to the physical properties of the carbon used. The vapours so absorbed can be released again, and the carbon regenerated by treatment with steam. The carbon, after steaming, is dried and cooled, when it will again absorb vapour as before. In fact, the process of absorption and desorption can be continued almost indefinitely.

In the practical application of this principle the activated carbon is placed in layers of suitable thickness in vessels called adsorbers. The air stream containing the vapours of solvent to be recovered is drawn through the carbon till this becomes saturated. Regeneration is carried out by admitting live saturated steam into the adsorber. The mixture of steam

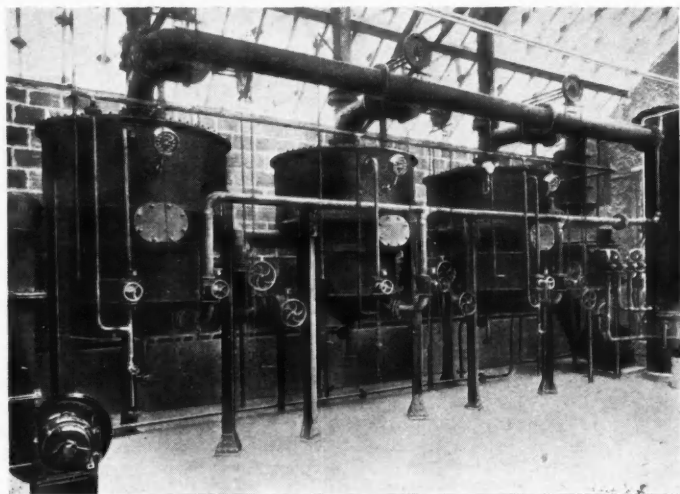
saturation, while the other is being distilled. After steaming the carbon is dried and cooled by suitable means, and the absorber is ready for its next cycle.



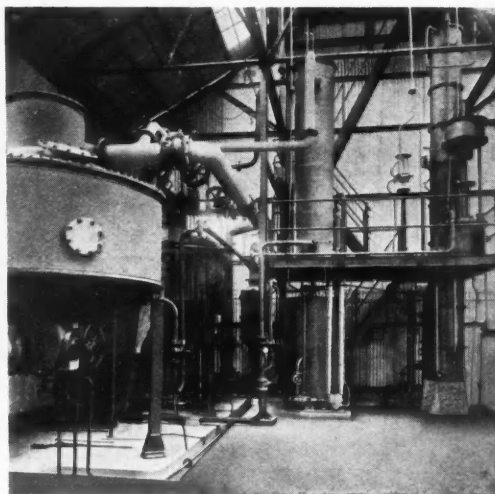
1.—Inlet of air charged with solvents. 2.—Filter. 3.—Fans. 4.—Adsorbers.
5.—Outlet of air free from solvents. 6.—Condenser. 7.—Decanter.
8.—Sight Glass.

A diagrammatic layout of a typical Continuous Recovery plant with two Adsorbers.

The great practical advantages of the process as above outlined are its very high efficiency under practical conditions, and the fact that mixtures of solvent in air at extremely low concentrations can be treated with ease and without loss of efficiency. For example, it is common practice to operate



A modern installation for recovery of naphtha with three adsorbers.



Recovery and rectification plant: rectification plant for water soluble solvent shown on right.

and solvent vapour goes forward to a condenser, at the exit of which a mixture of water and the liquid solvent is obtained. If two or more adsorbers are used, the process can be made continuous, one adsorber being in the phase of

such a plant with a concentration of solvent in air of 5/10 grams to the cubic metre where the lower limit of concentration to produce an inflammable mixture is, say, about 50/60 grams to the cubic metre.

It will be clear that this has two very definite practical advantages in the design of a solvent recovery plant: (1) The safety of the whole system, as it can be operated with an air stream throughout containing vapour at the low concentrations mentioned, and very much below the concentration which can propagate flame. (2) The possibility of using a large volume of air for collection of solvent vapours and so of obtaining a high degree of collection from the manufacturing process concerned.

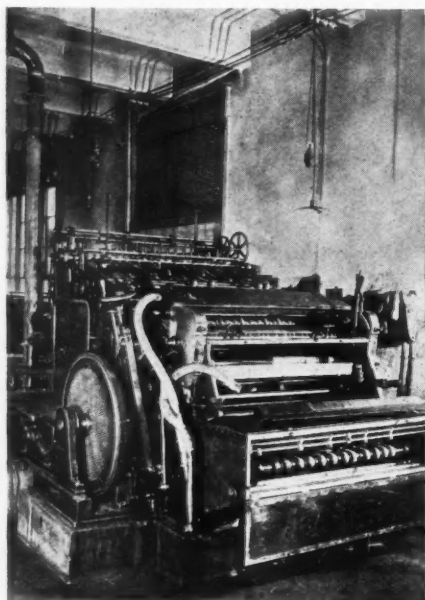
To return briefly to the efficiency of the whole system, it was mentioned above that absorption by activated carbon is almost complete. A modern recovery plant, working at concentrations of, say, 10 or 20 grams of solvent vapour to the cubic metre will give an efficiency of 95 per cent. measured on the solvent vapour passing through the plant, and, in fact, by careful design and expert control efficiencies of up to 98 per cent. or even more can be obtained. The practical efficiency of the whole system from the point of view of the manufacturer will depend, however, on the amount of vapour which can be collected and passed through the system. Some

disulphide, etc. If water soluble solvents are present, these must be treated in a dehydrating or fractionating plant, after preliminary separation of the insoluble solvent if necessary. In actual practice, as mixed solvents are frequently used, complicated problems of separation may occur, and a good practical experience of solvent recovery problems involves a wide practical knowledge of distillation principles.

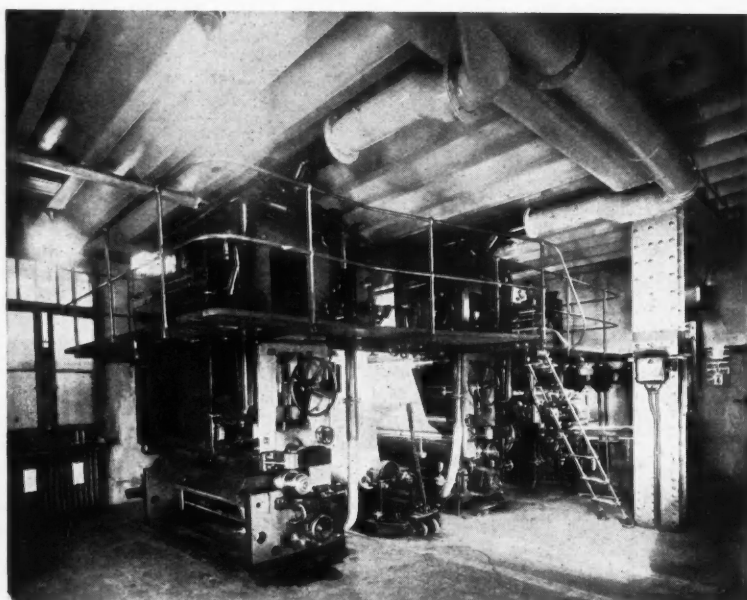
The development of the activated carbon process of recovery has been rapid, and progress during the last few years has been largely concerned in the more detailed study, not only of the properties of the activated carbons themselves, but also of the chemical engineering principles involved in the absorption plant proper, in the separation of recovered solvents, and in the practical problems of ventilation concerned with the collection of vapours.

Special Properties

Even to attempt to summarise the work which has been done in the study of the properties and of the manufacture of absorbent carbons for various purposes would demand a re-



Collection of vapours for recovery from a plate photogravure machine.



Collection of vapours for recovery from a rotary photogravure machine.

processes naturally lend themselves to a much more efficient collection of vapour than others. For example, if the process using the solvent can be carried out in an almost closed chamber, the efficiency of collection can be very high, and the greater part of the solvent given off in vapour can be led through the plant. In such cases, practical recovery efficiencies of 90/95 per cent. can be obtained. If, however, the process is such that a considerable degree of open working is essential, the technique of ventilation becomes extremely important in order to collect the greatest volume of vapour to pass through the recovery plant. Even with some extremely difficult processes, by the use of the principles of ventilation and special devices for collection of vapour, efficiencies of 70 per cent., 80 per cent. or even more are obtainable.

Treatment of Condensed Liquid

There is a further point to be considered in the brief summary of the process given; that is the treatment of the condensed liquid so as to procure solvents ready for use again in the process of manufacture. If the mixture of solvent and water recovered at the condenser contains a solvent insoluble in water, the separation is easy by ordinary methods of decantation. This applies to such solvents as trichloroethylene, carbon tetrachloride, naphtha, benzene, carbon

view by itself, but it may be said, that as a result of this work, activated carbons are now produced with special properties suitable for a very wide range of absorption problems. Hardness, speed of absorption, high coefficient of absorption, and utilisation, ease of desorption are all characteristics to be considered, and all have great importance from the practical point of view of plant design.

The design of the absorption plant has been steadily improved to give higher and higher efficiency, increased economy in operating costs, ease of control, and reasonable capital outlay. Hence economic schemes of recovery can now be proposed to manufacturers whose consumption of solvent was formerly considered too small to justify the inclusion of a recovery plant in their process.

The development in methods of collection of vapours is perhaps best dealt with by indicating in brief review some of the problems which are now current practice in solvent recovery.

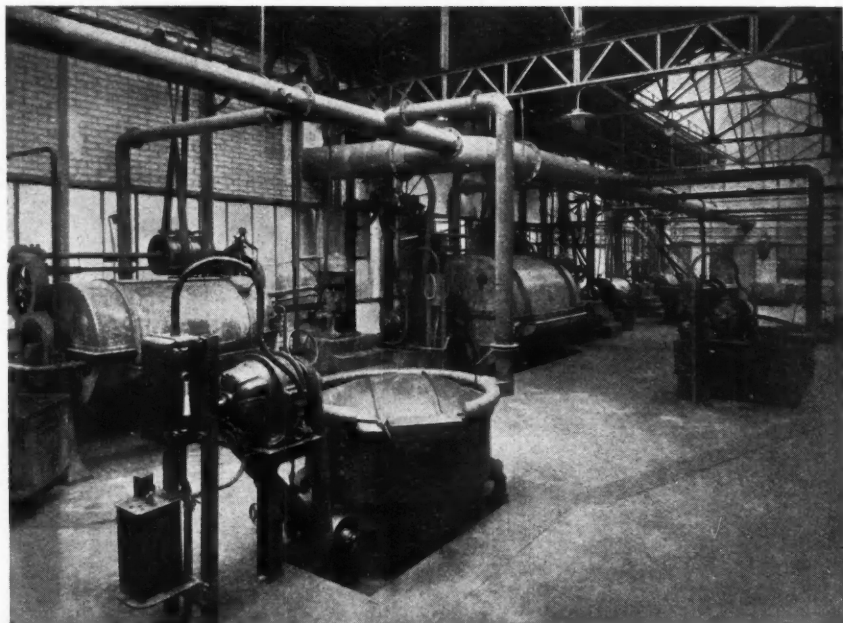
The recovery by activated carbon is almost essential where solutions of rubber in solvents are used, for example, in spreading the material for waterproofs, tennis balls, tyre fabrics, in the manufacture of dipped gloves, and so on. The methods of collection of vapours have reached a high efficiency, and practically every spreading shop is equipped with specially designed hoods for the collection of the vapours

leading to the recovery plant. Recoveries of about 80/85 per cent. are obtained, and the conditions of operation in the room greatly improved.

The process of leather cloth manufacture is usually carried out on spreading machines where hoods of a similar type to those for rubber spreading are used. The same high degree of recovery is obtained, and conditions in the work rooms vastly different from formerly are now the rule. The solvents concerned are usually mixed solvents, involving rectification plant with the recovery plant. Total efficiencies of 80/85 per cent. are regular practice. Consider, also, the manufacture of moisture-proof transparent wrappings. In the placing of a

of alcohol equivalent to about 1 per cent. of their total production. In addition, the fermentation gas can be very efficiently purified, so that it is rendered specially suitable for the production of liquefied or solidified carbon dioxide for alimentary purposes.

In the production of lacquered and coloured aluminium foils for wrapping, the coating material is dissolved in a mixed solvent, and this industry therefore presents a typical recovery problem. A large works has been equipped for this process, the collection of solvent vapours being carried out from numerous machines of different types. The recovery plant includes rectification apparatus, and the total efficiency obtained,



Collection of vapours for recovery in a dry cleaning works.

proofing coat on the viscose film, a dope made up with solvents is used, and without recovery of a high degree of efficiency, the process would be hardly economic. With a well-designed coating plant, and careful control of ventilation, recovery efficiencies exceeding 90 per cent. and even reaching 95 per cent. can be obtained in this industry.

Photogravure printing is a fairly recent development, and presents a very complicated problem from the point of view of solvent recovery. In this process, inks made with a solvent base such as xylol, benzine, ethyl acetate, etc., are used on rotary and other presses, and as the speed of printing is high, rapid drying of the paper is essential. If this vapour is dispersed into the air, the concentration of solvent is very low. However, by wide practical trials and careful study of the main types of machines used in the process, remarkably efficient collection can now be given, and recovery efficiencies of 70/80 per cent. can be obtained. In other words, from the point of view of the practical printer, a recovery of 100 per cent. calculated on the thinner added is possible, as the ink issued to the press room already contains a proportion of solvent. Good collection in gravure work can be obtained not only on rotary machines, but also on high speed flat machines, and it will be readily understood that the conditions throughout the works are very much more healthy than in works not provided with such equipment—apart from the economy.

Treatment of Gases at Distilleries

An interesting example of the efficiency of the activated carbon process is given by the treatment of the gases given off during fermentation at distilleries. These gases, besides containing a percentage of alcohol, also contain higher alcohols, aldehydes and various other products, all of which can be removed by passing through activated carbon. A large number of distilleries are so equipped to-day, and obtain a recovery

namely, 80 per cent. overall, is remarkably good. In addition, the improvement in the health conditions in the works is most marked.

The dry cleaning industry, in particular, is a large consumer of solvent, and the process is available not only to the large works with considerable consumption, but also to small units, including even the shop window cleaning plants. The manufacture of balata belting, jointing material, cables and surgical plasters often involves the use of solvents, and excellent recovery can be obtained by suitable methods applied to each process. In the manufacture of film, artificial silk, celluloid articles, certain boot and shoe fabrics, numerous recovery problems also exist, and can be solved by the activated carbon process.

Solvent extraction plants can operate with much lower solvent losses when recovery plants of this type are connected to the condenser exits. This applies to the extraction of oil seeds, of bones for grease manufacture, extraction of flowers for manufacture of perfume, and so on.

FOR the preservation of water solutions and emulsions containing vegetable and animal proteins, gums, etc., the Glyco Products Co. are offering two materials which are of considerable interest. Under the names of Moldex and Aseptex (Tech.), these two products are recommended for retarding mildew, fermentation, and mold growth in vegetable gums, casein, glue, gelatine, etc., wherever these products are used for non-edible purposes. Being dry powders, they can be incorporated in the dry products themselves or water, glycerin or alcohol solutions can be made if desired. Both Moldex and Aseptex (technical grades) are finding considerable application in the textile, paper, leather, polish, cosmetic and similar fields.

Cellulose Ester Lacquer Solvents and Plasticizers

A Review of Modern Products

THE firm of A. Boake, Roberts and Co., Ltd., have been manufacturing cellulose ester lacquer solvents at their Stratford Works right from the inception of the lacquer industry in this country, and during the thirty odd years that have passed since then have kept abreast with the developments that this rapidly expanding industry has made, with the result that to-day they are offering solvents to specifications undreamed of twenty-five to thirty years ago.

Nitro-cellulose has been known almost a century but it is less than sixty years since a satisfactory solvent was discovered for it. In 1881 Stevens suggested the employment of amyl acetate and from that date the history of cellulose lacquers may be said to have begun. Amyl acetate on this account is regarded as the doyen of all solvents and A.B.R. commenced its manufacture in 1905, not in very large quantities it is true nor judged by present day standards of very high quality; but in those days an ester content of 60 per cent. to 80 per cent. was considered all that could be reasonably demanded. But as the years passed so technique advanced, the quality of raw materials improved, better methods of esterification were introduced, and with the introduction of more efficient fractionating columns the undesirable ingredients were eliminated with the result that to-day amyl acetate is being produced regularly and in large quantities to a very rigid specification giving a narrow boiling range and high ester content.

Dope for Aeroplane Fabrics

The war years brought about a very great demand for dope for aeroplane fabrics, and there was such a demand for amyl acetate that a shortage was threatened. However, at this time large quantities of acetone were being manufactured by fermentation processes, and during this process butyl alcohol was produced, regarded as a useless by-product and jettisoned. A.B.R. realised that butyl acetate had possibilities as a solvent and with almost unlimited supplies of butyl alcohol available were very soon turning out as much butyl as amyl acetate, with the result that to-day butyl acetate has usurped the latter's position and is now the most widely used lacquer solvent. The years 1915, 1916 and 1917 saw enormous developments; plants were equipped for the large scale production of methyl and ethyl acetates, and triacetin with an ester content of close on 100 per cent. was at that time being produced in fair quantity.

As the technique of lacquer manufacture advanced so the demand for efficient plasticizers increased and A.B.R. commenced the manufacture of tricresyl and triphenyl phosphates in 1915, and although dogged for many years with the colour bogey finally laid him low and in time produced these phosphates so that they remained colourless in the finished film. Various other plasticizers followed these, and by 1920 lactates, tartrates, citrates and propionates, together with diacetone alcohol, were being produced on the commercial scale. Within the next half dozen years or so further new products were introduced, outstanding among which were butyl and amyl stearates, and the glyceryl benzoates. By this time the rush to obtain new solvents, especially the high boilers, had died down, and although new products were still being introduced the greater part of the research chemists' time was devoted to consolidating and improving already well established products.

A New Field in Cellulose Lacquer Work

Within the last few years attention has been devoted to plasticizers for special purposes, particular attention being given to the cellulose ethers which are likely to open up a new field in cellulose lacquer work. Attention must here be drawn to the series of Abracols, many of which are designed to fulfil a special purpose. Particularly interesting among

these are the ethyl and butyl derivatives of acetyl ricinoleic acid which, on account of their lubricating properties, bid fair to oust castor oil from the position it has hitherto held as a plasticizer for leather lacquers. The series of cresyl glyceryl ethers and their derivatives are of recent introduction, and find particular application in the plastification of cellulose ethers. Of very recent introduction are the derivatives of butylene glycol which are excellent plasticizers for both cellulose acetate and nitrate yielding hard, clear, flexible films. Butylene glycol citrate, being a thick, transparent, water soluble liquid, has been suggested as a substitute in some instances for glycerine and may prove a valuable material.

Mention of the pioneer work among solvents can hardly be considered complete without some reference to ester gum. Boake, Roberts and Co. commenced the manufacture of this material in 1917, and here again were beset with difficulties regarding colour; however, in time the process was improved and they were enabled to offer a standardised grade with a very pale colour and low acid value.

Properties and Uses

Having traced the history of many of the important solvents let us return to a more detailed discussion of the properties and uses of the different products as they are offered to the lacquer manufacturer to-day. The most important solvents and those most widely called for are prepared by esterifying certain aliphatic alcohols with acetic acid. The lowest member of this series is methyl acetate, which however is not a very widely used solvent on account of the ease with which it is hydrolysed by water, and also by reason of its being manufactured from methyl alcohol which is a poisonous material. It possesses an evaporation rate similar to that of acetone which it may in some instances replace.

Ethyl acetate, butyl acetate and amyl acetate are "the big three" of the solvents world and nearly all cellulose lacquers contain a proportion of at least one of these. Ethyl acetate is rapidly becoming widespread as a low boiling lacquer solvent possessing as it does considerable advantages over acetone; having a higher boiling point and much lower evaporation rate it is far less likely to cause chilling, and at the same time has a far greater tolerance for alcohols and paraffins. Butyl acetate is now the most widely used lacquer solvent, being non-toxic and having a less powerful odour than amyl acetate. It is probably the best solvent for cold lacquers since it is sufficiently volatile to leave the film readily and yet not so volatile as to cause blushing. Amyl acetate, with the possible exception of butyl acetate, is still the most widely used solvent; its one great handicap is its powerful "banana" odour which is objected to in some cases even though it is quite harmless. In spite of this handicap, however, its superior solvent qualities are so marked that its odour is usually tolerated on that account.

An Interesting Series

The formates can in some cases replace the corresponding acetates, but being somewhat unstable esters their use is only recommended in special instances. The propionates, particularly those from butyl and amyl alcohols, are sometimes employed in brushing lacquers where it is desirable to introduce a less volatile constituent and promote a good secondary flow. The lactates form an interesting series, particularly ethyl lactate, which is one of the most important of the high boilers having particularly high solvent powers and tolerating considerable dilution with non-solvents and even up to 25 per cent. of water. The slowness of its evaporation is in some respects a disadvantage, but in brushing lacquers it may well be incorporated to retard evaporation and promote smooth impermeable films.

The acetins, more especially diacetin and triacetin, are very

useful plasticizers where a soft film is required particularly with cellulose acetate and are also valuable plasticizers for use with glyptals. The phthalates enjoy a wide popularity as cellulose ester plasticizers, dibutyl phthalate sharing with tricresyl phosphate the honour of being most widely used.

In conclusion mention must be made of the citrates which have come into vogue recently as plasticizers for cellulose acetate and nitrate. Triethyl citrate can be used in proportions up to 100 per cent. of the cellulose ester, and tributyl citrate in proportions almost as great.

The Solvent-Using Industries

By LOUIS LIGHT, Ph.D. (Zurich), A.I.C.

SOLVENTS find application in a large number of distinct fields. They may roughly be classified under the headings of low-boilers (b.p. below 100° C.), medium-boilers (b.p. up to 140° C.) and high-boilers (b.p. up to 200° C.).

Low Boilers.—Ethyl ether, ethyl alcohol, ethylene dichloride, methyl alcohol, methyl acetate, acetone, ethyl acetate, isopropyl ether, methylene chloride, isopropyl alcohol, trichlorethylene, methyl ethyl ketone, isopropyl acetate, benzene.

Medium Boilers.—Dioxan, butyl acetate, amyl acetate, butyl propionate, butyl alcohol, amyl alcohol, methyl propyl ketone, methyl isobutyl ketone, toluene, ethylene glycol monoethyl ether, ethylene glycol monomethyl ether, ethylene glycol monobutyl ether, methyl amyl alcohol, dibutyl ether.

High Boilers.—Diacetone alcohol, cyclohexanone, methyl cyclohexanone, furfural, ethylene glycol monoethyl ether acetate, ethylene glycol monomethyl ether acetate, ethyl butyl acetate, diethylene glycol ethyl ether, dichlorethyl ether, turpentine, white spirit, tetrahydronaphthalene, decahydronaphthalene, and benzyl alcohol.

Cellulose Lacquers

While nitrocellulose is still the leading cellulose derivative in lacquer manufacture (as well as in the related industry of thermoplastic products) the special qualities of other members such as cellulose acetate, ethyl cellulose, and benzyl cellulose are being increasingly recognised. The above selection of solvents and diluents will be found to provide suitable solvent combinations for any of these derivatives.

Just as nitrocellulose has retained the leading place in cellulose finishes since its introduction, so has butyl acetate remained the ideal solvent for lacquers made from nitrocellulose in spite of the penetrating odour. Its all-round excellence as well as the price factor have contributed to its supremacy. Similarly, butyl alcohol still remains indispensable in the formulation of lacquers with butyl acetate, being unexcelled as a blender, flow-promoter and viscosity-reducer. Nitrocellulose spraying lacquers are generally based upon ethyl acetate or acetone as the active solvent, but even here both butyl acetate and butyl alcohol cannot be usually omitted, even though the proportion may be cut down to 4 to 5 per cent. in favourable atmospheric conditions. Among solvents which have gained favour as a partial substitute for butyl acetate where residual odour is undesirable are the methyl, ethyl and butyl ethers of ethylene glycol, butyl propionate, and methyl isobutyl ketone, all of which have become available in the last few years at comparatively low prices.

Cellulose acetate lacquers still continue to be hampered by the relatively small range of medium and high boiling solvents. The medium boilers are here represented by ethylene glycol monomethyl ether, methyl isobutyl ketone-ethylene dichloride and dioxan (although pending further data on the toxicity of the latter, it should be used with great caution), the high boilers by diacetone alcohol, cyclohexanone and ethyl lactate. Beta-trichlorethane (b.p. 114° C.) is an interesting newcomer in this field as it dissolves cellulose acetate in the presence of a small amount of an alcohol. This chlorinated hydrocarbon is not unduly toxic and is exceptionally stable to moisture and oxidising factors.

Ethyl cellulose and benzyl cellulose do not suffer from this handicap, being soluble in cheap mixtures. An interesting re-

cent addition to the cellulose ester class is cellulose acetobutyrate. This mixed ester dissolves in acetone, ethyl acetate, ethylene dichloride, ethylene glycol monomethyl ether and ethyl lactate and the solutions tolerate very considerable dilution with aromatic hydrocarbons. It is also compatible with a wider range of plasticizers and resins.

Nitrocellulose Aeroplane Dopes

The necessity for speedy application of nitrocellulose aeroplane dope lacquers over the enormous wing span of modern machines leads logically to the use of those solvents and diluents with very high rate of evaporation—acetone, ethyl acetate, isopropyl acetate, methyl acetate, methylene chloride, methyl ethyl ketone, methyl alcohol, ethyl alcohol, and benzene. Chilling in humid atmospheres is then avoided by minimum proportions of the medium and high boiling solvents and diluents (methyl isobutyl ketone, ethers of ethylene glycol, butyl acetate, butyl alcohol, benzyl alcohol, etc.).

Nitrocellulose and other readily soluble cellulose derivatives find application in numerous other directions, e.g., in artificial leather manufacture (by application of thick dopes to a fabric base), patent leather finishes, adhesives (water-proof), safety glass bonding layers, moulding compositions (sheet, rod, tube, powder and tablet), stencil paper and stencil pastes, rust removers, metal degreasers, transparent paper (from solutions of cellulose acetate and benzyl cellulose). Many solvents among those listed at the outset will be found useful in dissolving resins. Apart from their well-established value as oil varnish and cellulose lacquer components, many natural and synthetic resins are suitable, when dissolved, for such purposes as paper-coatings, millinery finishes, lamp varnishes, and certain classes of cheap furniture and toy varnishes.

The basis of most paint and lacquer strippers is an active, highly volatile solvent (acetone, methyl acetate or methylene chloride) containing a small percentage of a viscosity-imparting agent (wax, cellulose acetate, chlorinated rubber, etc.).

Shellac Solutions

For average industrial purposes, ethyl alcohol remains by far the most widely used solvent for making shellac varnishes. Many of the newer solvents are also good solvents for shellac and find application particularly when it is desired to blend shellac with other classes of substances. Examples of modern shellac solvents are butyl alcohol, isopropyl alcohol, hexyl alcohol, ethyl acetate, dioxan, ethylene glycol monoethyl ether and ethylene glycol monobutyl ether. In the same way the solvents can be varied to suit particular requirements when preparing solutions of resins such as manila, sandarac rosin and sandarac.

While shellac stands without a rival among natural or synthetic resins in respect of the elasticity of its coatings, there are now many synthetic alternatives to copal, rosin, manilac, sandarac, etc. The outstanding achievement of recent years has certainly been the production of colourless, hard and chemically inert materials at an economic price possessing solubility in a wide range of common solvents. They include polystyrol, polymethyl methacrylate, cyclohexanone resin and polyvinyl acetate.

A fairly wide range of solvents is now available for dissolving rubber and the solutions are used for a great variety

of purposes ranging from rubber proofing of textiles to the manufacture of rubber articles by dipping. In addition to the older solvents (benzene, toluene, xylene, carbon tetrachloride and carbon bisulphide) the manufacturer of rubber solutions can now avail himself of cyclohexanone, methyl cyclohexanone, ethylene chloride and methylene chloride.

Paints and Varnishes

The oil paint and varnish industry is probably one of the oldest solvent-users in history. It continues to absorb vast quantities of white spirit, turpentine and coal tar aromatics, but is taking increasing quantities of more recently introduced solvents. Among the more important of these are butyl alcohol, dipentene (a by-product of turpentine manufacture), tetrahydronaphthalene, decahydronaphthalene and cyclohexanone.

A recent development is the employment of solvents in "laminated" cloth manufacture, layers of soluble artificial textiles being softened by the solvent and fused together by heat and pressure.

The viscose process absorbs vast quantities of carbon bisulphide in the manufacture of cellulose xanthogenate while acetone is the principal solvent in cellulose acetate rayon production. In the latter case, a very high percentage of recovery is essential to economic working.

Textile Assistants and Scouring Agents

Excellent possibilities in the manufacture of so-called soluble oils and coupling agents in textile finishing are provided by the water-soluble ethers of the various alkylene glycols. Diethylene glycol monobutyl ether (b.p. 231° C.) is soluble in both water and oils and thus forms a mutual solvent for soaps, oils and water. Diethylene glycol also possesses good coupling action and increases the solubility of soaps used in making soluble oils. Similar uses have been found for triethylene glycol (b.p. 288° C.) which is used when a higher boiling point is essential. Textile soaps are also conveniently prepared with a proportion of methyl alcohol (b.p. 64.5° C.) which is miscible with water and oils and the same applies to isopropyl alcohol (b.p. 82° C.).

Among the chlorinated solvents, dichlorethyl ether (b.p. 178° C.) is useful in promoting the action of soap solutions at high temperatures. When present in scouring agents for raw wool, it assists removal of paint and tar brand marks. It is used in compositions with ordinary soaps as well as with sulphonated oils to give satisfactory wetting-out agents and penetrants. It is a solvent for cotton wax.

Octyl alcohol (b.p. 185° C.) is a good penetrant in the cotton mercerising process when used in admixture with cresols.

Dyestuffs Solvents

The glycol ethers are likewise growing in popularity for the production of textile dyeing solutions and pastes. Bright shades and fast colours are obtained when using ethylene glycol monoethyl ether and the diethylene glycol monoethyl ether gives similar results. The penetrating power of the former also renders it valuable in setting of twist and conditioning of yarn and cloth. Ethylene glycol monomethyl ether (b.p. 124° C.) is a good solvent for spirit-soluble dyes and increases their penetration into vegetable and animal textiles.

Dioxan (b.p. 101° C.), soluble both in water and organic solvents, is a solvent for oil-soluble dyes, but not for the water-soluble and spirit-soluble types. In the former case it has been found to act as an excellent dispersing agent in dye baths and dye compositions. A high boiling solvent widely applicable in the preparation of dye solutions is diethylene glycol (b.p. 244° C.). It finds use, for instance, in non-drying printing pastes (owing to its hygroscopicity) and yarn-tinting solutions. It is incidentally a good softening agent for all the common vegetable and animal fibres to which it imparts increased flexibility and stretch. Tetrahydrofurfuryl alcohol (b.p. 182° C.), only recently available at a commercial price, is completely miscible with water and has found application as a textile dye solvent. 2,3-Butylene glycol (b.p. 180° C.) is

also now obtainable at an attractive price and merits attention in the preparation of non-drying printing pastes. It has some of the hygroscopic properties of glycerine. Sorbitol is for the same reason of interest in this field.

The high solvent power of furfural coupled with its penetrating power have led to its use as a component of shoe dyes.

Extraction Processes

Up to recent years the solvents in common use in extraction treatment of fats, oils, waxes, alkaloids and essential oils were carbon tetrachloride, ether, benzene, alcohol, petrol, acetone, and white spirit. This range has now been considerably widened by the commercial production of such products as methylene chloride, isopropyl ether, dibutyl ether, dioxan, dichlorethyl ether, ethylene dichloride, propylene dichloride and trichlorethylene.

Isopropyl ether (b.p. 67.5° C.) is less soluble in water than ordinary ether and can therefore be more completely recovered. It is an effective extraction agent for nicotine from tobacco. The dibutyl ether (b.p. 143° C.) is completely insoluble in water and will replace the two lower homologues in extraction processes where it is desired to reduce the fire hazard. It is important to note that all the 3 ethers form peroxides in storage which explode violently when heated. These can be readily destroyed, however, by treatment with sodium sulphite solution. Their presence is readily detected by appearance of a brown colour within a few minutes after adding sodium iodide or potassium iodide solution.

Trichlorethylene (b.p. 86° C.) is completely non-inflammable, a point that may decide some users in its favour in preference to ethylene dichloride which is close to it in boiling point (83° C.), but can be ignited (even though with difficulty). It is also notable for its stability and resistance to hydrolysis, qualities that it shares with beta-trichlorethane (b.p. 114° C.).

Some Miscellaneous Uses

In admixture with isopropyl alcohol at low temperatures, isopropyl ether becomes a poor solvent for paraffin wax which is thus conveniently separated. Furfural has likewise become an important selective solvent in petroleum refining.

Dry cleaning soaps containing petrol as the "dry" cleaner, are improved by a proportion of ethylene glycol monobutyl ether which permits the incorporation of enough water to aid removal of water-soluble stains. In the same way, diethylene glycol monoethyl ether is a good coupling agent for mineral oil-soap mixtures.

Trichlorethylene is eminently suitable for degreasing leather, bones, feathers, wool and the like. Its value in the dry-cleaning of textiles, etc., naturally follows. Where a ketonic solvent of higher boiling point and reduced solubility in water is desired in place of acetone, good use can be made of methyl ethyl ketone. (b.p. 85° C.), methyl propyl ketone (b.p. 105° C.) and methyl isobutyl ketone (b.p. 118° C.).

A member of the glycol class with interesting possibilities in this field is propylene glycol (b.p. 187° C.). Unlike ethylene glycol which may conceivably be oxidised to the highly toxic oxalic acid in passing through the body, propylene glycol is physiologically harmless. This fact also recommends it to the pharmaceutical manufacturer to whom it will also appeal as a superior general solvent to glycerine. Ethylene glycol monoethyl ether is also growing in popularity as a vehicle for food flavours, perfumes and pharmaceutical products.

GERMANY has organised systematic measures for collecting bones on a national scale, the results of which are already very encouraging. The discarding of bones by households by burning or in garbage is disapproved, and all available agencies are being patriotically enlisted for effecting maximum and systematic collection of bones from households, restaurants, etc. The sum of 1 pfennig per kilogram is paid for all bones delivered by persons other than school children. Stress is placed upon recovery of bones in view of their great value for manufacturing glue.

Solvents and Plasticizers of the Cyclohexanol Series

Their Characteristics and Applications

HOWARDS and Sons, Ltd., specialise in the manufacture of solvents and plasticizers of the cyclohexanol series, although they also manufacture other types.

Sextone (cyclohexanone) and Sextone B. (methylcyclohexanone), having boiling ranges 150°-158° C. and 160°-175° C. respectively and flash points 117° F. and 130° F., are widely used as solvents of the "medium boiler" type in introcellulose and synthetic resin lacquers, spirit varnishes and bitumen paints. They are particularly useful in lacquers on account of their high solvent powers for introcellulose and synthetic and natural resins and for imparting good flow and gloss, low viscosity, excellent adhesion (especially on leather) and very high blush resistance: another valuable property is their high dilution ratio to toluol, xylol and white spirit.

Sextol (methylcyclohexanol), boiling range 160°-180° C., flash point 156° F., is a powerful solvent for fats, oils, waxes, many dyes, a large number of synthetic and natural resins, shellac, etc. In addition it possesses excellent wetting-out and emulsion stabilising properties. Sextol, therefore, is a valuable ingredient in textile, laundry and dry-cleaning soaps, dye-baths, textile printing pastes, emulsifying agents, synthetic resin lacquers, paints, plastics, polishes, insecticides and disinfectants.

Ethyl lactate, boiling range 145°-160° C. (95 per cent.), flash point 125° F., is a useful solvent in nitrocellulose, cellulose acetate and synthetic resin lacquers and plastics, in leather-cloth and in spirit varnishes; it shares with Sextone and Sextone B. the advantages of very good solvent properties and high dilution ratios and of imparting good flow, low viscosity and high blush resistance: it is a "high-boiler."

Diacetone Alcohol

Diacetone alcohol, boiling range 160°-170° C. (92 per cent.), flash point 130° F., is a "high boiler" used in introcellulose and cellulose acetate lacquers and plastics, in spirit inks and in hydraulic brake fluids: it is particularly suitable for this last purpose on account of its low volatility, high flash-point and low freezing point, stability on heating and its complete absence of action on rubber and metals.

Acetal solvent, boiling range 75°-85° C. (90 per cent.), is used in introcellulose and synthetic resin lacquers as a "low boiler," having an evaporation rate intermediate between those of ethyl and butyl acetates. In conjunction with alcohol soluble cotton it is useful for producing clear lacquer films with resins which usually give difficulty in blending: its low cutting power makes it particularly suitable for final coats.

Dipentene, boiling range 175°-185° C. (90 per cent.), flash point 130° F., is a cheap solvent of the terpene class widely used to prevent "skimming" in oil varnishes and synthetic resin finishes; it also improves flow and gloss. It is a useful solvent for chlorinated rubber. Being an excellent wax solvent and having a pleasanter odour than turpentine it is used in many wax polishes.

Cyclohexane, boiling range 81°-84° C., is used for recrystallisation purposes in the fine chemical industry and for the extraction of essential oils; it is an ideal solvent for these purposes on account of its sharp boiling-point, pleasant odour and price. It is one of the most powerful solvents so far put on the market for paraffin wax and for crude rubber.

Glycerol lactate, stable up to 200° C. without boiling, is a water-soluble solvent of very low volatility; it is an exceptionally powerful solvent for a wide range of dyes and is used in textile printing and in certain types of inks.

Cyclohexylamine has only just been put on the market; it is a water soluble basic solvent, boiling point 135° C., having a high solvent power for many classes of dyes and having great possibilities in textile dyeing and printing and as an emulsifier.

Technical ethers "730" and "720" are solvent ethers of

narrow boiling range used for industrial and laboratory extraction purposes and for "spotting" stains.

Howards and Sons, Ltd., make a range of plasticizers which are distinguished by their stability to light. Barkite B. (dimethylcyclohexanol oxalate) and Barkite (methylcyclohexanol oxalate) are used in introcellulose lacquers and plastics and in certain types of synthetic resin lacquers; they have good blending powers for introcellulose, resins and oils, impart a high gloss to lacquer films and are widely used in whites and cellulose leather finishes: they have good wetting power for pigments. They are also used to prevent skimming in certain types of inks.

Sextol stearate is incorporated in cellulose leather finishes to improve gloss, glazing and water resistance and in water-pigment finishes to improve flow. It is an excellent plasticizer for chlorinated rubber and has the additional advantage of high stability to alkalis and acids. Sextol phthalate is a plasticizer of very low volatility, good stability to heat as well as to light, and very high viscosity. Its use is growing rapidly in introcellulose and synthetic resin finishes, especially in high temperature storing finishes, and also as an exceptionally good plasticizer for all types of shellac.

Plassitil is a moderate priced plasticizer for cellulose acetate of especial interest to manufacturers of plastics and cable dopes; it is compatible with cellulose acetate in all proportions and is insoluble in petroleum hydro-carbons and unmiscible with mineral oils.

Cellulose Acetate Plasticizers

Three New Products

THREE recently introduced plasticizers for cellulose acetate are of particular interest owing to the special properties which they confer to the acetate film. Softener AL imparts resistance to oils and petrol fuels, so that finishes to meet such demands can now be formulated. For cable lacquers, in particular, this oil resistance is of great value. Softener 90 with cellulose acetate gives really remarkable ageing properties and elasticity, since it is practically non-volatile, while an addition of approximately 1 per cent. of Cetamol QU to acetate lacquers will render them completely non-inflammable. Cetamol QU also serves to decrease very considerably the inflammability of nitrocellulose lacquers.

In the chlorinated rubber field, the best resistance to chemical action—an important use of chlorinated rubber—can only be obtained with unsaponifiable plasticizers. For many years such a plasticizer with sufficient elasticity was missing, but this gap has been filled during the last few months by the introduction of Desavin, a pale yellow oil, which gives even better elasticity than the saponifiable dibutyl phthalate previously used. Clophen A.60 is another invaluable unsaponifiable plasticizer for chlorinated rubber. Desavin is also remarkable in being suitable for use in lacquers for foodstuff wrapping papers, having no objectionable effect.

Few lacquer solvents of note have been introduced recently. Butoxyl and Solvent MBO, both complex glycol ethers, may be mentioned: they are excellent solvents for nitrocellulose, of only faint odour, and improve the flowing properties very considerably.

PRODUCTION of benzol in the United States estimated by the Bureau of Mines, from the production of coke at by-product ovens known to recover this commodity, amounted to 30,628,000 gallons during the first quarter of 1937 compared with 22,910,000 in the corresponding period of 1936. The term "benzol" represents crude and refined benzol plus motor benzol.

Carbon Tetrachloride (C.T.C.)

By R. G. STILTON, of Albright and Wilson, Ltd.

CARBON TETRACHLORIDE, CCl_4 , is one of the most important of the series of chlorinated hydrocarbons which, by reason of their physical properties and non-inflammability, are finding an increasing application as solvents in a wide variety of industries.

The pure substance is a clear, colourless liquid with a pleasant aromatic odour somewhat resembling that of chloroform. It boils at 76.8°C . (170.2°F .) and has a specific gravity of 1.629 at 0°C . Both the liquid and the vapour are non-inflammable and non-explosive, even when mixed with air, and the fact that the heavy vapour has a "smothering" effect on flames has caused it to become widely used as a component of fire-extinguishers. In this connection, the high "break-down voltage" of C.T.C. makes it especially suitable for extinguishing fires in places where there is electrical equipment. It is readily miscible with most organic solvents, including the aliphatic alcohols and ethers, acetone, benzene, petroleum and coal tar naphthas, chlorinated hydrocarbons, acetic anhydride and many esters.

When mixed with inflammable solvents, C.T.C. has the effect of raising the flash point, and suitable mixtures of C.T.C. with these solvents are often used where it is desired to lower the cost or to increase the range of solvent action. C.T.C., moreover, has a powerful solvent action on fats, mineral and vegetable oils, waxes, rubber and various rubber preparations, and certain resins. It will thus be seen that there is a great variety of industries where this solvent may usefully be employed, and a few of these are enumerated below.

Dry Cleaning Practice

Of recent years the chlorinated hydrocarbons have largely replaced the inflammable solvents in dry-cleaning practice, owing to their non-inflammability and superior solvent power. The only drawback to the use of C.T.C. in this connection has been its corrosive tendency towards certain of the common metals in the presence of moisture, which must inevitably be present in dry-cleaning operations. Certain plants are, however, constructed of monel metal and other resistant alloys, and then the problem of corrosion does not arise. Owing to its low boiling point, C.T.C. is easily recovered and no lingering odours are left behind in the cleaned garments. It should be noted that it may be used for cleaning dyed artificial silk of all types without danger of the colours "running." Also it is stable and may be repeatedly distilled without undergoing decomposition. Many non-inflammable dry-cleaning fluids prepared for home use consist of C.T.C. or mixtures of C.T.C. with other solvents.

C.T.C. is frequently used for the removal of the natural oil from leather, and for the removal of grease and oil with which the leather may have become contaminated in the course of manufacture. In the textile trade, C.T.C. is useful for the removal of oil and grease spots from fabrics, and has also been used for "scouring" raw wool, in which operation the use of inflammable solvents would be dangerous owing to the possible production of sparks from static electricity. It is also a component of many liquid textile soaps.

Metal Degreasing

Many metal finishing operations, such as bonderising or electroplating, require a completely oil- and grease-free surface obtained by immersion cleaning in C.T.C. Since there is no fire hazard connected with its use, it is also widely used for cleaning the grease from various types of machinery, such as engines, electric motors, typewriters, etc.

The low surface tension of C.T.C. enables it to penetrate readily into fibrous materials, such as oil seeds, and it is finding an application in the extraction and purification of vegetable oils and in the extraction of caffeine and various other alkaloids.

General solvent uses of C.T.C. include the preparation of rubber cements, paint and lacquer removers, polishes, stains and waxes. It is also often employed as a solvent for the impregnation of wood, fabrics and paper with materials which are water-insoluble. Owing to its inability to take up further quantities of chlorine, it is useful as a solvent in certain chemical processes involving chlorination.

Toxicity of Carbon Tetrachloride

In common with those of other organic solvents, the vapours of C.T.C. have a harmful effect on the human body when inhaled in relatively large concentrations, but the danger to the health of workpeople from this cause may be removed if precautions are taken to ensure adequate ventilation of buildings where the solvent is used (preferably by means of a down-draught system, as the vapour of C.T.C. is heavier than air).

Ten Years' Oil from Coal Progress

Colonel W. A. Bristow's Review

COLONEL W. A. BRISTOW, chairman of Low Temperature Carbonisation, Ltd., in his speech at the annual meeting at Winchester House, London, on Tuesday, said that "Coalite" smokeless fuel was now distributed by more than 5,000 merchants and at Barugh, Askern (South Yorkshire) and Bolsover (Derbyshire) more than 8,000 tons of coal a week were being carbonised and despatched. During the past five years, an increasing number of Home Defence Squadrons of the R.A.F. had been supplied with coal petrol and motorists who used Carless-Coalene mixture agreed that the performance of their cars had much improved as a result.

About two years ago the company erected at Barugh a new type of plant for the extraction of the tar acids from the crude oil produced by the "Coalite" process. This plant had proved difficult to operate, but the difficulties had now been overcome and the plant was working at its rated output. The products had proved of great value and were in considerable demand. The company was already exporting large quantities of tar acids for use as a froth flotation reagent in copper mining, and they had a wide application in many industries, especially in the manufacture of disinfectants and germicidal products. In addition, as a result of the work carried out at the Chemical Research Laboratory, Teddington, under the direction of Sir Gilbert T. Morgan, it had been demonstrated that there was no fundamental difficulty likely to be encountered in the use of the company's products, for the production of the synthetic resins required for the rapidly expanding plastics industry. In view of the probable further expansion of this industry in the next few years, it was of interest to note that in a comparatively short time the company would be the largest producers of tar acids in this country.

Following upon the success that attended the preparation and marketing of the products from the first plant at Barugh, the directors had now decided to construct a second plant in Derbyshire, at a cost of approximately £200,000. A third plant would be included in the general scheme in South Wales. Contracts had already been placed for the main items for the Derbyshire plant and most of the products had been sold up to 1940.

All the results which the Royal Commission on the coal industry hoped might be obtained had already been achieved in ten years of development and research. Further developments were confidently anticipated.

Authority was given to raise the capital from £1,275,000 to £2,000,000. A dividend for the five months' period of 4 per cent. was agreed, giving 9.6 per cent. for the full year.

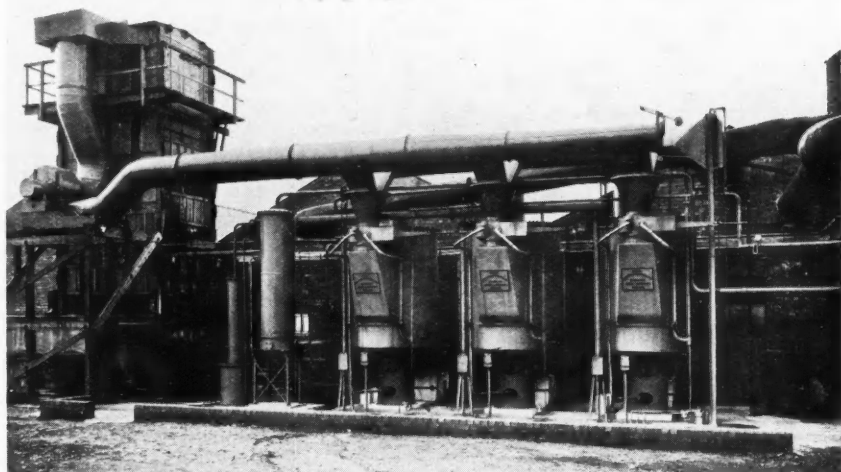


Fig. 1. A modern carbon bisulphide recovery plant, recovering four tons per week.

Advances in Solvent Recovery

By E. R. SUTCLIFFE

ADVANCES that have been made in solvent recovery in recent years have been considerable, and where the solvent used is of a value justifying it, there is no reason why exceedingly high efficiencies cannot be secured in recovery, efficiencies ranging up to 95 per cent. and over being readily procurable. This makes it possible for manufacturers to foresee the use of more expensive solvents in their processes, solvents which under conditions without recovery would be quite out of the question owing to the cost.

Furthermore, it enables manufacturers to foresee the substitution of some of the more expensive non-inflammable solvents in place of the inflammable solvents. Where it is possible to use these non-inflammable solvents, the cost of plant might be reduced for the reason that when an inflammable solvent is used, great precautions have to be taken to avoid risk of fire and explosion, and this entails most generally the movement of very large volumes of air in order to keep quite outside the lower explosive limit. Such precautions with non-inflammable solvents are not at all necessary, and all that has to be taken care of is that sufficient air is being moved to ensure collection of the vapours.

Improved Recovery Efficiency

Many plants are in operation to-day where over 90 per cent. recovery is common practice, and in one well-known tyre manufacturer's plant the writer was told by the managing director that if at any time their recovery fell below 93 per cent., immediate steps were taken to find out why there was this loss of recovery. This is a case where the recovery plant, spreading machines, mixing machines, and storage tanks are all in the one room, and the 93 per cent. spoken of includes all the spirit that is brought into that room, so that it corresponds to a measurement of what is taken out of the tank and what goes back into the tank.

Amongst some of the more interesting plants that have been recently set into operation includes the extension to Ferguson Shiers and Co., Ltd., Phoenix Mills, Failsworth, near Manchester, where they already have a solvent recovery plant comprising some five adsorbers for naphtha recovery, and where some 4,000 gal. are being recovered per week. There has now been added an interesting installation for the recovery of carbon bisulphide; an illustration of this plant is shown in Fig. 1. This plant comprises the necessary scrubbing tower for extracting the sulphur and acid products formed by the composition of sulphur chloride.

The recovery plant has been designed with particular regard to safety, and it is interesting to note that the installation of the recovery plant has undoubtedly reduced the risk of fire and explosion in using this very inflammable and dangerous solvent.

Another interesting plant which has been installed, and an illustration of which is shown in Fig. 2, is that of David Moseley and Sons, Ltd., Chapel Field Works, Ardwick, Manchester, in connection with their rubber spreading machines. This plant is capable of handling 24,000 cu. ft. of air per minute from the rubber spreading room, and is giving very satisfactory recovery figures. Not only does it recover from the spreading room, but also from the mixing room and other drying apparatus.

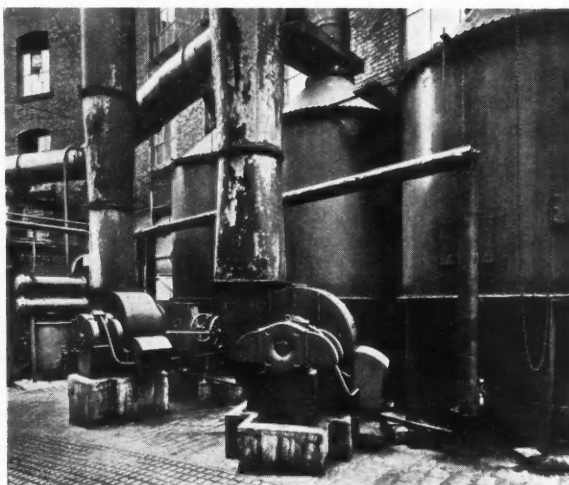


Fig. 2. Naphtha recovery plant, recovering from 24,000 cu. ft. of air per minute.

Another important recovery plant is that installed for the Northern Rubber Co., Ltd., Victoria Works, Retford, Notts. In this particular works a solvent recovery plant in connection with the spreading room has been in use for some years. Their present extension will bring it up to an output of something like 5,000 gal. per week, with an overall efficiency of 90 per

cent, measured from tank to tank. A carbon bisulphide recovery plant, which has now been in operation for the past month, is recovering approximately four tons of carbon bisulphide per week, with a very high efficiency factor.

An installation in connection with the recovery of mixed solvents in the manufacture of leather cloth, which is shown in Fig. 3, has also been installed in the Yorkshire area. In this particular installation a rectifying still has had to be provided for separating the solvent from the watery condensate secured on steaming off the adsorbers. It includes a number of interesting developments.

Smaller Recovery Plants

Smaller recovery plants, in which great strides have recently been made, are in connection with trichlorethylene in the smaller dry cleaning works. A large number of such plants have now been installed, and it may be said that no installation of this character can now be considered complete without its recovery plant. Plants suitable for this purpose

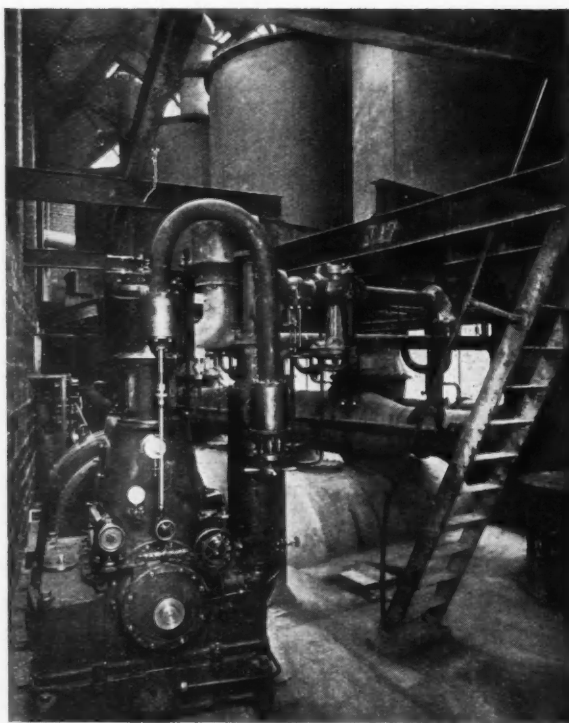


Fig. 3. An installation for the recovery of mixed solvents in the manufacture of leather cloth.

are made with a single adsorber in connection with small outputs, whilst in the case of larger outputs double adsorbers are in use. It is interesting to note that the development of installing these recovery plants seems, in many cases, to have increased their throughput considerably, and extensions of the solvent recovery plant have had to be made in order to cope with the increased business that has accrued. Many of the larger dry cleaners using white spirit have now either installed recovery plant or have placed orders for same.

In all the cases mentioned, the installations have been constructed by Sutcliffe, Speakman and Co., Ltd., Leigh, Lancs., who we understand now, claim to be the world's largest manufacturers of activated carbon.

The Japanese Department of Commerce and Industry will ask for an appropriation of Yen 23,500 during the coming fiscal year, to be used as a subsidy for the experimental production of benzol from coal tar. It is understood that the primary purpose is to produce a sufficient amount of this product to supply the growing demand for anti-knock fuels in aviation.

Institute Examination Papers

Extracts from the Examiners' Report

THE June issue of the Journal of the Institute of Chemistry contains an abstract of the board of examiners on the April-May examinations for the Associateship and Fellowship of the Institute, in which 89 candidates were examined and 54 passed.

The report states that in the examination for the Associateship in general chemistry, the papers in inorganic theory seemed well within the capacity of the candidates, certain of whom did exceptionally well. The general standard was higher than usual and this is reflected in the higher percentage of passes in the whole examination. Some candidates tended to devote too much time to the earlier answers with the result that their later answers showed signs of hurried treatment. The practical work, as a general rule, was satisfactorily done. The exercise that was least satisfactorily carried out was the estimation of the purity of the barium peroxide. For a satisfactory result the selection of the correct acid for solution is very important.

In organic chemistry a number of candidates did not read the questions with sufficient care and consequently did not give the information required or gave it only in a curtailed form, e.g., in questions asking for the principal reactions of diazo-compounds and the uses of certain reagents much time was devoted by several candidates to describing the preparation of these substances. The knowledge of the uses of phenylhydrazine as a reagent appeared in some answers to be limited to its application to sugar chemistry.

In answering a question on the stereoisomerism of the tartaric acids some candidates started with the assumption that tartaric acid contains two asymmetric centres and proceeded to make various deductions from it. On the other hand several candidates answered the question in a very satisfactory manner and dealt with the experimental findings first. Some candidates were unacquainted with the uses of thoria as a catalyst. Except by several obviously ill-prepared or weak candidates the practical work was done quite well and a good proportion of candidates completed the exercise and prepared well crystallised specimens.

In the examinations for the Fellowship a general weakness was shown with regard to ability to write reports. Special attention is called to the fact that a candidate for the Fellowship of the Institute should show ability to write reports on his work in a clear and concise manner.

Dealing with the chemistry (including microscopy) of food, drugs and water, the report says there was a tendency for some candidates to assume that when they had found something wrong with a sample it must be correct in all other respects. Thus when a sample of camphorated oil was found to be deficient in camphor some candidates thought that a certificate might be given on this point without an examination of the base to see whether it was, as it should be, olive oil. Some candidates gave information for which they were not asked. This may have been due to their not reading the questions carefully.

There was some weakness in pharmacology and candidates should remember that a reasonable knowledge of the action of the commoner drugs on the body is expected. The mere repetition of doses and scientific terms and the recognition of vegetable drugs is not sufficient. There is still weakness in descriptions of microscopical work and sketches were often scanty and of poor quality.

MASON AND BARRY, LTD., London, leading producers of pyrite in Portugal, report pyrites output in 1936 at 144,547 metric tons and sales at 165,729 tons. Corresponding figures for 1935 were 133,893 and 120,313 tons, respectively. Sulphur shipments during 1936 were 8,032 metric tons. The company produces elemental sulphur from chalcopyrite ore by a Norwegian process.

School Girl's Laboratory Accident Function of the Chemical Merchant

Claim Against Suppliers of Chemicals

DAMAGES amounting to £3,119 were awarded by the Lord Chief Justice in the King's Bench Division on June 16 to Marjorie Juliette Kubach, a 13-year-old schoolgirl, who lost an eye in an explosion in a laboratory at Park School, Lancaster Road, South Norwood, in January, 1936. The original claim was against the headmistress of the school, and Townson and Mercer, Ltd., who supplied the chemicals employed in the laboratory. The second defendants brought in Frederick Allen and Sons (Poplar), Ltd., manufacturing chemists, of Upper North Street, E., as third party.

The jury found that there was no negligence or breach of contract on the part of the headmistress, and judgment was given against Townson and Mercer, Ltd.

The claim by Townson and Mercer, Ltd., for an indemnity from Frederick Allen and Sons (Poplar), Ltd., who, they asserted, had sold them as manganese dioxide a chemical containing antimony sulphide which, with another chemical, caused the explosion, was heard on June 17.

After discussion it was decided to proceed without the jury, who were accordingly discharged.

Mr. R. Thomas, for Townson and Mercer, Ltd., contended that it was the irresistible inference from the evidence which he had to offer that the chemical sold by Townson and Mercer, Ltd., to the school as manganese dioxide came from the premises of Frederick Allen and Sons (Poplar), Ltd. He therefore asked for indemnity from that company on the ground of breach of contract. It was agreed that the invoice which accompanied the chemical sold to Townson and Mercer, Ltd., bore the words: "These goods are accurate as described when leaving our works, but they must be examined and tested by the user before use," but he submitted that that did not relieve the sellers from the liability under their contract to supply the actual article demanded.

Mr. N. L. Macaskie, for Allen and Sons, said that the warning on the invoice applied both to Townson and Mercer, Ltd., and to that company's customers. It was denied that there had been misdirection or mistake by his clients—who had no knowledge of the ultimate use to which the chemical would be put—which could fix them with liability for injury to a subsequent user.

Mr. Thomas replied that there was an equal duty on the part of Frederick Allen and Sons (Poplar), Ltd., to test the chemical before it left their premises.

At the conclusion of the argument his Lordship said that, in view of the importance of the case and the amount of money involved, he would consider his judgment and deliver it in the course of a few days.

South African Salt Industry

IN the past salt has been regarded as an obstacle in the development of the Bechuanaland Protectorate, but now that an attempt is being made to discover whether the large salt pans can be turned to commercial use it may prove an asset. The main asset of the territory is its native-owned cattle, and as there is only a limited market for this in the Union, it has been decided to encourage the export of hides. Salt is the cheapest and most convenient means of preserving these, and it is now suggested that the Government should exploit the local salt-pans. Samples from possible suppliers have been submitted to the Imperial Institute in London for examination and report, and this chemical analysis has shown the salt to be of good quality and suitable for the cattle industry. The main obstacle to opening up the Bechuanaland salt pans is transport, for most of these pans are far from the railway. The native chiefs are stated to be in favour of the project, and ready to help in any way possible. South Africa now has 39 salt producers, who produce more than 80,000 tons, valued at about £250,000 a year, and is thus able to provide for her own needs.

Service to Customers

AN increasing number of new solvents, plasticizers, synthetic resins and emulsifiers are in demand by research chemists. One of the chief functions of the modern chemical merchant and agent is therefore to have on tap through his connections in countries the world over, the various new products that are produced on a commercial scale or even in the initial laboratory stages. This service to customers is much appreciated as the buyer and the chemical departments are usually far too busy to be able to lay their finger on all the latest products developed throughout the world.

Rex Campbell and Co., Ltd., are good representatives of what can be done in this connection. They market an extensive range of glycol solvents, ketones, hydrocarbons, and numerous specialities when called for. They also offer a large number of allied products such as special emulsifiers for every purpose, synthetic gums and resins, waxes, pearl and luminous pigments.

Many people in the past have rather jumped to the conclusion that the merchant was a middleman and should be sidetracked if possible. In the chemical trade, if not in others, it can truly be said that he performs most useful functions, one of many being that he enables manufacturers to obtain supplies of standard and also unusual products without delay or trouble. He stabilises the price, as he of necessity must study the market conditions very closely with the view to buying at the lowest possible price. In consequence, in the majority of cases, the manufacturer is able to purchase his supplies at a lower price than if he went direct, particularly when he only requires a small quantity of goods from abroad.

Cheaper Solvents

Results of Improved Methods

DURING the past year, in contradistinction to the majority of chemicals, there has been a steady reduction in the price of the more commonly used solvents such as butyl alcohol and butyl acetate. This has been effected chiefly by the greatly increased demand and improved methods of manufacture and the fact that modern processes and raw materials, except for the basic molasses, are almost exclusively synthetic. The rise in price of primary raw materials has had no effect. The industry is continually undergoing a process of rearrangement, partly due to fundamental price change and partly to new developments of the industries concerned, and, consequently, the proportions and kind of solvents that are being used and will be used are likely to vary considerably during the next few years. At the present time the cellulose lacquer and synthetic finishes consume at least 75 per cent. of the current production.

The Chemical Supply Co., Ltd., has kept well in advance of recent developments and research has been intensified with a view to satisfying all modern requirements in the large field which their products cover; these include the lacquer, paint, chemical, plastic, pharmaceutical, cosmetic, essence, glass, enamelling, refractory and rubber industries.

It would be difficult to enumerate the miscellaneous industries in which solvents are consumed, such as the manufacture of explosives, tobacco, dry cleaning, printing inks, and even the household refrigerator, but enough has already been presented to indicate that the outlook for expansion in the solvent field is not limited to those industries that now provide the principal market for solvents. The trend is very definitely toward new industrial uses of products employing new solvents.

The future solvent consumer will doubtless become more critical than his predecessor, and not only will the products of this industry be higher in quality, but they must also bear assurance of a stabilised price rendered possible by efficient production.

The Chemical Age Lawn Tennis Tournament

Results of Second Round Matches

THE matches in the second round of the seventh annual CHEMICAL AGE Lawn Tennis Tournament were completed on Tuesday, and the results, together with the full list of competitors, are given in this and following pages. Except in the case of the finals, players drawn against each other must make their own arrangements for playing off the match on a court mutually agreed upon. In the event of disagreement the first name drawn has the right to choose the ground. The best of three advantage sets will be played in each round.

It is important that competitors should bear in mind the closing dates for the various rounds as shown at the head of each of the two draws. Results must be sent to the Editor of THE CHEMICAL AGE immediately after the match, and must in any case reach him not later than first post on the day following the final day for playing off the round.

Whilst there will be no new draw for each successive round, a draw will be made for the right of choice of ground and competitors will be notified accordingly.

Alphabetical List of Players

The following alphabetical list indicates names of all competitors in The Chemical Age Lawn Tennis Tournament. Addresses and telephone numbers are given to facilitate communication between players.

- Allen, F. R. O. (Nobel Finishes, Ltd., Slough, Bucks. 'Phone: Slough 528; ext. 55).
- Barnes, S. (British Oxygen Co., Ltd., Angel Road, Upper Edmonton, N.18. 'Phone: Tottenham 2488).
- Baxter, A. (United Yeast Co., Ltd., 238, City Road, E.C.1. 'Phone: Clerkenwell 0303).
- Bennett, R. A. J. (Nobel Chemical Finishes, Ltd., Slough, Bucks. 'Phone: Slough 528; ext. 55).
- Blow, D. G. (British Drug Houses, Ltd., 18-30, Graham Street, City Road, N.1. 'Phone: Clerkenwell 3000).
- Bowden, E. F. (Le Grand, Sutcliffe, and Gell, Ltd., The Green, Southall, Middx. 'Phone: Southall 2211).
- Bowler, H. (Nobles and Hoare, Ltd., Cornwall Road, S.E.1. 'Phone: Waterloo 4694).
- Brewer, G. (Corn Products Co., Ltd., Bush House, Aldwych, W.C.2. 'Phone: Temple Bar 2091).
- Britnell, E. (County of London Elec. Supply Co., Ltd., Generating Station, Creeks Mouth, Barking. 'Phone: Rippleway 2461).
- Burnham, C. J. (C. J. Hewlett and Sons, Ltd., 35, Charlotte Street, E.C.2. 'Phone: Bishopsgate 1172).
- Chaloner, S. E. (Monsanto Chemicals, Ltd., Ruabon, Denbighshire. 'Phone: Ruabon 3).
- Champkin, R. A. (B. Laporte, Ltd., Kingsway, Luton, Beds. 'Phone: Luton 891).
- Copp, C. G. (Doulton and Co., Ltd., High Street, Lambeth, S.E.1. 'Phone: Reliance 1241).
- Cornelius, L. (Stafford, Allen and Sons, Ltd., 7, Cowper Street, Finsbury, E.C.2. 'Phone: Cle 2100).
- Cosgrove, A. (Hanovia, Ltd., Bath Road, Cippenham, Slough. 'Phone: Burnham 500).
- Crosse, F. G. (Society of Chemical Industry, 46-7, Finsbury Square, E.C.2. 'Phone: Met 3773).
- Darton, F. (J. Buchanan and Co., Ltd., 26, Holborn, E.C.1. 'Phone: Holborn 6183).
- Eager, J. (Griffiths Bros. and Co., Ltd., Macks Road, Bermondsey, S.E.16. 'Phone: Bermondsey 1151).
- Eastwell, J. S. (British Xylonite Co., Ltd., Hale End, London. 'Phone: Larkwood 2345).
- Eyres, A. F. (Johnson Matthey and Co., Ltd., Hatton Garden, E.C.1. 'Phone: Hol 6989; ext. 49).
- Giltrow, L. (Williams (Hounslow), Ltd., Hamworth Road, Hounslow. 'Phone: Hounslow 1166).
- Goudie, A. W. A. (Corn Products Co., Ltd., Bush House, Aldwych, W.C.2. 'Phone: Temple Bar 2091).
- Gough, C. G. (Lever Bros., Ltd., C.T.D./G. Dept., Port Sunlight, Cheshire. 'Phone: Rock Ferry 500; ext. 110).
- Grape, L. F. (Borax Consolidated, Ltd., Regis House, King William Street, E.C.4. 'Phone: Mansion House 8331).
- Hammond, G. (Williams (Hounslow), Ltd., Hounslow, Middx. 'Phone: Hounslow 1166).
- Hancock, E. T. (Murex Welding Processes, Ltd., Ferry Lane Works, Forest Road, Walthamstow, E.17. 'Phone: Larkwood 2284).
- Hand, F. D. (B. Laporte, Ltd., Kingsway, Luton, Beds. 'Phone: Luton 891).
- Hann, J. S. (Griffiths Bros. and Co., Ltd., Macks Road, Bermondsey, S.E.16. 'Phone: Bermondsey 1151; Private: Buckhurst 0030).
- Hanson, G. A. (Whiffen and Sons, Ltd., Carnwath Road, Fulham, S.W.6. 'Phone: Fulham 0037).
- Hardee, J. E. (W. J. Bush and Co., Ltd., Ash Grove, Hackney, E.8. 'Phone: Clissold 0461).
- Hawkes, K. W. (George Scott and Son, Ltd., Artillery House, Artillery Row, S.W.1. 'Phone: Vic 8708).
- Hayman, R. D. (Doulton and Co., Ltd., 120, Granville Street, Birmingham. 'Phone: Mid 1315).
- Healey, P. E. (Chemicovens, Ltd., Vintry House, Queen Street Place, E.C.4. 'Phone: Cen 3381).
- Herridge, W. H. (British Xylonite Co., Ltd., Hale End, London. 'Phone: Larkwood 2345).
- Hole, G. W. (Anglo-Samon Pet. Co., Ltd., St. Helen's Court, Leadenhall Street, E.C.3. 'Phone: Avenue 4321; ext. 107).
- Hoppe, W. (Johnson Matthey and Co., Ltd., Hatton Garden, E.C.1. 'Phone: Hol 6989; ext. 49).
- Hornsby, R. H. (Howards and Sons, Ltd., Uphall Works, Ilford, Essex. 'Phone: Ilford 3333).
- Hudson, J. (Bakelite, Ltd., 68, Victoria Street, S.W.1. 'Phone: Vic 5511).
- Hughes, A. E. (Limmer and Trinidad Lake, Asphalt Co., Ltd., Steel House, Tothill Street, S.W.1. 'Phone: Whitehall 6706).
- Jones, J. I. T. (The Mond Nickel Co., Ltd., Thames House, Millbank, S.W.1. 'Phone: Vic 5353).
- Killick, A. A. (B. Laporte, Ltd., Kingsway, Luton, Beds. 'Phone: Luton 891).
- Lacy, E. D. (Murex Welding Processes, Ltd., Ferry Lane Works, Forest Road, E.17. 'Phone: Larkwood 2284).
- Law, R. S. (Howards and Sons, Ltd., Uphall Works, Ilford, Nr. London. 'Phone: Ilford 3333).
- Lewis, W. R. (British Oxygen Co., Ltd., Angel Road, Upper Edmonton, N.13. 'Phone: Tottenham 2488).
- Liston, R. E. (Walter Carson and Sons, Ltd., Grove Works, Lombard Road, Battersea. 'Phone: Battersea 2451; ext. 31).
- Lusty, H. H. (Bakelite, Ltd., 68, Victoria Street, S.W.1. 'Phone: Vic 5511).
- Marcar, A. S. (Bovril, Ltd., 152, Old Street, E.C. 'Phone: Clerkenwell 2202).
- Marchant, W. (Doulton and Co., Ltd., 120, Granville Street, Birmingham. 'Phone: Mid 1315).
- Maronge, L. A. (Bakelite, Ltd., 68, Victoria Street, S.W.1. 'Phone: Vic 5511).
- Mayers, W. P. (British Drug Houses, Ltd., 16-30, Graham Street, City Road, N.1. 'Phone: Clerkenwell 3000—Export Dept.).
- Oakley, W. (W. J. Bush and Co., Ltd., Ash Grove, E.8. 'Phone: Clissold 0461).
- O'Brien, P. D. (B. Laporte, Ltd., Kingsway, Luton, Beds. 'Phone: Luton 891).
- O'Connor, F. (Murex Welding Processes, Ltd., Ferry Lane Works, Forest Road, E.17. 'Phone: Larkwood 2284).
- Pavitt, E. (Co-Operative Wholesale Society, Ltd., Drug Works, Greenside Lane, Droylsden, Manchester. 'Phone: Droylsden 1348).
- Plant, J. H. G. (Gas Light and Coke Co., Kings Road, Fulham, S.W.6. 'Phone: Fulham 5531).
- Porter, R. F. (Howards and Sons, Ltd., Uphall Works, Ilford, Essex. 'Phone: Ilford 3333).
- Pugh, G. (British Oxygen Co., Ltd., Angel Road, Edmonton, N.18. 'Phone: Tottenham 2488).
- Prosser, V. (John Haig and Co., Ltd., Kinnaird House, 2, Pall Mall E., S.W.1. 'Phone: Whitehall 1040).
- Robbins, W. A. (Le Grand, Sutcliffe and Gell, Ltd., The Green, Southall, Middx. 'Phone: Southall 2211).
- Rolfe, G. L. (Brandhurst, Co., Ltd., Vintry House, Queen Street Place, E.C.4. 'Phone: Cen 1411).
- Rowley, E. (British Oxygen Co., Ltd., Angel Road, Edmonton, N.18. 'Phone: Tottenham 2488).
- Scott-Bloxam, T. C. (Le Grand, Sutcliffe and Gell, Ltd., The Green, Southall. 'Phone: Southall 2211).
- Sleap, R. J. (United Yeast Co., Ltd., 238-240, City Road, E.C.1. 'Phone: Clerkenwell 0303; ext. 3).
- Smith, C. G. (Shell Mex and B.F., Ltd., Shell Mex House, Victoria Embankment, W.C.2. 'Phone: Temple Bar 1234; ext. 311).
- Smith, E. (Riley Harbord and Law, Parliament Buildings, Orchard Street, S.W.1. 'Phone: Abbey 3104).

- Speakman, W. (Monsanto Chemicals, Ltd., Ruabon, Denbighshire. 'Phone: Ruabon 3).
- Thedford, C. (Monsanto Chemicals, Ruabon, Denbighshire. 'Phone Ruabon 3).
- Tickner, A. H. (British Celanese, Ltd., 22, Hanover Square, W.1. 'Phone: Mayfair 8000; ext. 259).
- Thompson, V. D. (Stafford, Allen and Sons, Ltd., 7, Cowper Street, E.C.2. 'Phone: Clerkenwell 2100; ext. 3).
- Thomsett, E. A. (British Oxygen Co., Ltd., Angel Road, N.18. 'Phone: Tottenham 2488).
- Tickner, A. H. (British Celanese, Ltd., 22, Hanover Square, W.1. 'Phone: Mayfair 8000; ext. 259).
- Tinkler, R. (Murex Welding Processes, Ltd., Ferry Lane Works, Forest Road, Walthamstow, E.17. 'Phone: Larkwood 2284).
- Triggs, R. E. (Murex Welding Processes, Ltd., Ferry Lane Works, Forest Road, Walthamstow, E.17. 'Phone: Larkwood 2284).
- Truslove, A. J. (Johnson Matthey and Co., Ltd., Hatton Garden, E.C.1. 'Phone: Hol 6989; ext. 16).
- Tunstall, P. A. (Salt Union, Ltd., 20, Water Street, Liverpool, 2. 'Phone: Central 4370).
- Turner, J. H. W. (Griffiths Bros. and Co., Ltd., Macks Road, Bermondsey, S.E.16. 'Phone: Bermondsey 1151).
- Wakeman, W. E. (Johnson Matthey and Co., Ltd., Hatton Garden, E.C.1. 'Phone: Holborn 6989).
- Walker, J. E. (National Farmers' Union, 45, Bedford Square, W.C.1. 'Phone: Mus 7526).
- White, A. W. (Howards and Sons, Ltd., Uphall Works, Ilford, Essex. 'Phone: Ilford 3333).
- Whittaker, E. (A. C. Wells & Co., Ltd., Carnarvon Street, Cheetham, Manchester, 3. 'Phone: Blackfriars 8044; Cheetham Hill 1886, Private).
- Williams, H. (W. J. Bush & Co., Ltd., Ash Grove, E.8. 'Phone: Clissold 0461).
- Williams, I. (Monsanto Chemicals, Ltd., Ruabon, Denbighshire. 'Phone: Ruabon 3).
- Williams, R. M. O. (Imperial Chemical Industries, Ltd., Thames House, Milbank, S.W.1. 'Phone: Victoria 3828).
- Williams, T. P. (Lever Bros., Ltd., Port Sunlight, Wirral, Cheshire. 'Phone: Rockferry 500; Extension 110).
- Willshire, A. E. C. (Borax Consolidated, Ltd., Regis House, King William Street, E.C.4. 'Phone: Mansion House 8331).
- Wilson, J. S. (British Celanese, Ltd., 22, Hanover Square, W.1. 'Phone: Mayfair 8000; Extension 260).
- Woollard, J. K. (Murex Welding Processes, Ltd., Ferry Lane Works, Forest Road, Walthamstow, E.17. 'Phone: Larkwood 2284).

The Chemical Age Lawn Tennis Tournament

Men's Doubles

Players drawn against each other must make their own arrangements for playing off their match on a court mutually agreed upon. In the event of disagreement the first drawn shall have the right to choose the ground. The asterisk (*) indicates the first name drawn. Best of three advantage sets.

FIRST ROUND	SECOND ROUND	THIRD ROUND Results by JULY 12	SEMI-FINAL Results by AUGUST 16	FINAL September 4
*T. P. Williams and C. G. Gough	Williams and Gough, w.o.	*Chaloner and Speakman, 6-4, 6-4		
R. D. Hayman and W. Marchant				
*S. E. Chaloner and W. Speakman	*Chaloner and Speakman, 4-6, 6-1, 6-4	*Chaloner and Speakman, 6-4, 6-4		
C. Thedford and I. Williams				
*R. E. Triggs and R. Tinkler	*Prosser and Baxter, 6-4, 6-1	Prosser and Baxter, 4-6, 6-0, 6-2		
V. Prosser and A. Baxter				
*J. I. T. Jones and R. M. O. Williams	Lewis and Barnes, 6-4, 4-6, 6-4			
W. R. Lewis and S. Barnes				
*E. T. Hancock and J. K. Woollard	*Hancock and Woollard, 6-4, 7-5	*Hancock and Woollard, 7-5, 1-6, 6-3		
W. H. Herridge and J. S. Eastwell				
*J. H. W. Turner and J. Eager	Turner and Eager, 3-6, 6-2, 6-1			
R. F. Porter and R. S. Law				
*E. Dacre Lacy and F. O'Connor	*Willshire and Grape, 9-7, 6-3	Willshire and Grape, w.o.		
A. E. C. Willshire and L. F. Grape				
*L. Giltrow and H. Bowler	Giltrow and Bowler, 6-0, 6-2			
L. A. Maronge and J. Hudson				
*A. W. A. Goudie and G. Brewer	Goudie and Brewer, 6-2, 6-2	Result awaited		
P. E. Healey and G. L. Rolfe				
*F. C. Crosse and J. E. Walker	*Eyres and Hoppe, 8-6, 6-2			
A. F. Eyres and W. Hoppe				
*R. A. J. Bennett and F. R. O. Allen	Bennett and Allen, 6-1, 6-3	Hole and Smith, 6-3, 6-3		
F. D. Hand and P. D. O'Brien				
*G. W. Hole and C. G. Smith	*Hole and Smith, 6-3, 6-2			
C. G. Copp and E. Smith				
*R. A. Champkin and A. A. Killick	Champkin and Killick, w.o.	Truslove and Wakeman, 6-0, 1-6, 6-3		
V. D. Thompson and L. Cornelius				
*A. J. Truslove and W. E. J. Wakeman	*Truslove and Wakeman, 6-1, 6-4			
J. S. Wilson and A. Tickner				
*R. Sleep and F. Darton	Sleep and Darton, w.o.	*Sleep and Darton, 6-0, 6-1		
C. J. Burnham and D. G. Blow				
*A. W. White and R. Hornsby	*White and Hornsby, 6-2, 5-7, 6-1			
W. A. Robbins and E. Bowden				

The Chemical Age Lawn Tennis Tournament

Men's Singles

Players drawn against each other must make their own arrangements for playing off their match on a court mutually agreed upon. In the event of disagreement the first name drawn shall have the right to choose the ground. The asterisk (*) indicates the first name drawn. Best of three advantage sets.

FIRST ROUND	SECOND ROUND	THIRD ROUND Results by JULY 12	FOURTH ROUND Results by AUGUST 2	SEMI-FINAL Results by AUGUST 23	FINAL SEPTEMBER 4
C. Thedford.....	.....*bye	*Thedford, 6-4, 6-0			
E. Pavitt.....	..... bye				
*T. P. Williams.....	Williams, w.o....	Gough, 6-1, 6-2...			
S. E. Chaloner.....					
*E. Whittaker.....	*Gough, 6-1, 6-4..				
C. C. Gough.....					
*R. D. Hayman.....	Williams, 6-1, 6-4	*Williams, w.o....			
I. Williams.....					
*W. Speakman.....	*Tunstall, w.o....	Truslove, w.o....			
P. A. Tunstall.....					
*W. P. Mayers.....	Liston, w.o....				
R. E. Liston.....					
*A. J. Truslove.....	*Truslove, 6-3, 7-5				
J. I. T. Jones.....					
*P. D. O'Brien.....	*Crosse, 6-2, 6-3..	*Marcar, 6-3, 11-9			
F. G. Crosse.....					
*J. S. Hann.....	Marcar, w.o....	Williams, w.o....			
A. S. Marcar.....					
*R. S. Law.....	*Blow, w.o....				
D. G. Blow.....					
*A. A. Killick.....	Williams, 6-1, 8-6				
R. M. O. Williams..					
*T. C. Scott-Bloxam	*Hammond, w.o....				
G. Hammond.....					
*W. E. Wakeman...	Sleep, 6-0, 6-0....	*Sleep, 6-3, 2-6, 6-1	Baxter, 6-1, 6-4..		
R. J. Sleep.....					
*A. Baxter.....	Baxter, 6-1, 6-2..	Baxter, 6-2, 6-3..			
E. Britnell.....					
*R. F. Porter.....	*Hanson, 6-1, 6-1..				
G. A. Hanson.....					
*H. H. Lusty.....	*Goudie, w.o....	Goudie, 6-1, 6-8, 6-4			
A. W. A. Goudie..					
*J. E. Hardee.....	Hardee, 6-2, 6-2..	Plant, w.o.			
P. E. Healey.....					
*K. W. Hawkes.....	*Plant, 6-1, 3-6, 6-2				
J. H. G. Plant.....					
*R. A. G. Bennett...	Bennett, 7-5, 6-4				
L. A. Maronge.....					
*L. F. Grape.....	Grape, 6-1, 6-3...	Grape, 3-6, 6-1, 6-0			
G. L. Rolfe.....					
*A. E. Hughes.....	*Walker, 5-7, 10-8, 7-5				
J. E. Walker.....					
*H. Bowler.....	Bowler, 6-1, 6-2..	*Bowler, 6-4, 6-4..			
V. D. Thompson...					
*C. G. Copp.....	*Copp, 6-2, 6-2 ..				
J. S. Wilson.....					
*L. Cornelius.....	Cornelius, w.o....	Turner, 6-0, 6-0..			
E. Dacre Lacy.....					
*J. H. W. Turner...	*Turner, 6-1, 2-6, 6-3				
H. Williams.....					
*W. Oakley.....	Tickner, w.o.	*Tickner, w.o....			
A. H. Tickner.....					
*F. Darton.....	*Darton, 2-6, 6-3, 9-7				
E. A. Thomsett....					
*F. D. Hand.....	*Pugh, w.o.				
G. Pugh					
*A. Cosgrove.....	Cosgrove, w.o....	*Cosgrove, 6-1, 6-3			
E. Rowley					
L. Giltrow.....	.....*bye	Lewis, 7-5, 2-6, 6-4			
W. R. Lewis.....					

Personal Notes

MR. ROBERT YOUNG, of R. Young and Co., Ltd., chemical manufacturers, Cranstonhill Chemical Works, Elliot Street, Glasgow, died at Dalbeattie last week, aged 84.

SIR ALEXANDER GIBB, of Sir Alexander Gibb and Partners, consulting engineers, was elected president of the London Chamber of Commerce at its 55th annual meeting on Tuesday. Sir



Sir Alexander Gibb.

Alexander is a past president of the Institution of Chemical Engineers, president of the Institution of Civil Engineers, a member of the Society of Chemical Industry and engineer to the commissioners for the special areas. At the recent annual dinner of the Chemical Engineering Group he delivered a memorable address on "The Chemical Engineer and Industrial Planning." Sir

Alexander succeeds Sir Stephen Demetriadi, who had held the office for the past three years. Sir Alexander was not present, having left for Canada on a business trip a few days ago.

PROFESSOR A. O. RANKINE, of the Imperial College, London, has been appointed chief physicist to the Anglo-Iranian Oil Co., Ltd.

MR. LOUIS W. SMITH, a director of Fison, Packard and Prentice, Ltd., has been elected a director and chairman of Ambrose Shardlow and Co., in succession to the late Sir Cecil Partridge.

BAILIE MCINTOSH, convener of Glasgow Corporation Gas Committee, and Councillor Thomas Wilson have been appointed to attend the annual conference of the Society of Chemical Industry to be held at Harrogate from July 5 to 9.

MR. H. T. FOSTER has been appointed chief mining engineer to the Safety in Mines Research Board, in succession to Major H. M. Hudspeth, who has returned to the mines inspectorate as one of the Deputy Chief Inspectors of Mines.

MR. JAMES GRIEVE, Dundee, has been awarded a scholarship in metallurgy by the Department of Scientific and Industrial Research, valued at £120 a year for two years. He will study under the supervision of Professor R. Haig, at the Royal Technical College, Glasgow. Mr. Grieve, who is 23 years of age, is the son of a Dundee postman, and the first of three brothers to pass through the university. He was educated at the Harris Academy and graduated B.Sc., with first-class honours in chemistry, at University College, Dundee. He also gained the class medal and the Carnelley prize in chemistry, the latter being the highest award an honours student can receive.

Chemical Notes from Foreign Sources

Belgium

PRODUCTION of casein artificial wool (lanital) has been planned by a leading Belgian wool manufacturing concern.

Jugoslavia

As part of the current industrialisation plans, the State Salt Mines at Kreka in Eastern Bosnia are to be enlarged and modernised, oil exploration work is to be pushed forward and a large power station will be constructed at Viscegrad.

Hungary

SYNTHETIC resins are to be produced in a new factory now under construction by the Acetic Chemical Works. Use will be made of formaldehyde made by the same firm, while phenols will be supplied by the associated Salgotarjan concern.

Finland

ONE of the leading producers of medicinal chemicals, the Orion O.Y., has recently increased its share capital from 600,000 marks to 2.1 million marks.

FORMATION is announced of an albumen manufacturing concern, the C.Y. Faneriliima A.B. with a share capital of 100,000 Finnish marks. Up till now albumen for the plywood industry has been entirely imported (the total import figure for 1935 is given as 1,544 tons).

Russia

TESTS on the use of sheet rubber in road construction are being carried out in Moscow in collaboration with the Krasny Bogatyr Rubber Works.

REEDS will be used as the raw material at the new paper combine in Saratov where the output of paper for 1938 is estimated at 2,300 tons.

A LARGE factory for working up seaweed to iodine and other products is planned for construction at the beginning of next year in the vicinity of the White Sea port of Kemi.

Japan

Ozone is to be used for bleaching rayon by the Tatsumi Shoji.

VINYL resins are to be marketed shortly by the Nippon Gosei Kagaku K.K. who are also planning the production of cellulose acetate rayon and photographic film.

British Association of Chemists

Visit to the Distillers Company's Laboratories

A LARGE number of members and guests attended a reception and garden party at the laboratories of the Distillers Company Ltd., at Great Burgh, Epsom, Surrey, on June 19, at the invitation of Dr. and Mrs. J. Vargas Eyre, the occasion being a visit by the London Section of the British Association of Chemists. Dr. Vargas Eyre is president of the Association. A feature of the afternoon's activities was a tour of the laboratories, in which a wide variety of work is proceeding, particularly in connection with the development of yeast cultures. The guests included Mr. T. Hedley Barry; Dr. C. S. Garland (chairman, British Association of Chemists) and Mrs. Garland; Mr. G. T. Gurr (chairman, London Section) and Mrs. Gurr; Mr. J. B. P. Harrison (past president) and Mrs. Harrison; Mr. J. C. Mellersh and Mrs. Mellersh; Sir Gilbert Morgan (past president) and Lady Morgan; Mr. S. R. Price (past president); Mr. H. T. F. Rhodes (hon. editor); Mr. W. H. Woodcock (hon. treasurer) and Mrs. Woodcock; Mr. C. B. Woodley (general secretary); Miss W. Wright (vice-chairman of council and hon. secretary of the London Section); Dr. and Mrs. E. F. Armstrong; Mr. Ballantyne (director, Lever Bros.) and Mrs. Ballantyne; Dr. W. Cullen (president, Institution of Chemical Engineers) and Mrs. Cullen.

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From Week to Week

ROBINSON BINDLEY PROCESSES, LTD., have increased their nominal capital by the addition of £30,000 beyond the registered capital of £20,000.

THE NOMINAL CAPITAL of the Metal and Electric Chemical Products, Ltd., has been increased by the addition of £200,000 in £1 ordinary shares beyond the registered capital of £500. This increase is for the purpose of acquiring the undertaking of Holsunces, Ltd.

THE MEXICAN EAGLE OIL CO. announces that production for the weeks ended May 29, June 5 and June 12, 1937, was 377,000, 106,000 and 268,000 barrels respectively. A strike of the company's workmen started on May 27 and continued until June 8, when it was announced that the matter was to be submitted to arbitration. Previous to the strike the weekly output was around 660,000 barrels.

SCOTTISH INDUSTRIAL ESTATES, LTD., with Compact Chemicals, Ltd., a new company, have arranged a lease of a factory with floor space of 10,000 sq. ft. on the industrial estate at North Hillington, near Glasgow. The company's products will include shoe dressings, a number of fine chemical preparations, and toilet and bath preparations. The whole production will be standardised and the packings are to be made in Scotland. The factory, which is under construction, is expected to begin operations in August.

IN CONNECTION with its recently launched road development campaign, the British Road Federation has arranged for an extensive programme of addresses on road transport problems and the need for road improvement, to be given by leading personalities of the road industries in "key" centres all over the country, in the course of the next few weeks. Speakers will address representative clubs and meetings of business men, and will deal with their subject on a broad national basis, from the point of view of both national economy and public safety.

THE PAPERS read at a symposium organised by the British Section of the International Society of Leather Trades' Chemists in February, 1937, together with some of the discussions, are to be published by A. Harvey in a book entitled "Wetting and Detergency: Scientific and Technical Aspects." It is an important work for the chemist and physicist, whether industrial or academic, and is believed to be the first in the English language dealing with wetting and detergency. The volume will present, in a concise form, the most modern theoretical considerations of the subject, and their bearings on industrial problems. The foreword is contributed by Dr. W. Clayton, F.I.C.

A NEW BOOKLET ON ANTOSTAB entitled "A New Gonadotropic Follicle-Stimulating Hormone," has been issued by Boots Pure Drug Co., Ltd. Antosab is prepared from pregnant mares' serum and has a powerful action in stimulating ovulation and the secretion of the oestrogenic hormone by the ovary. Although the full therapeutic possibilities of this new sex hormone have not yet been explored, excellent clinical results have been obtained in the treatment of conditions associated with anterior pituitary and ovarian dysfunction, and extracts from the reports are included in the booklet. The booklet is available for the medical profession and copies may be obtained on application to the company.

THE BRITISH STANDARD SPECIFICATION for centrifuge tubes and sedimentation vessels for the determination of visible dirt in milk (No. 736), just published by the British Standards Institution, has been prepared at the request of and in co-operation with the Dirt in Milk Sub-Committee of the Analytical Methods Committee formed by the Society of Public Analysts. The centrifuge tubes are primarily designed for the determination of visible dirt in milk by the method developed by the sub-committee and described in its report. ("Analyst," 1937, Vol. 62, pp. 287-301). It is anticipated, however, that the tubes may be found of use in other operations besides the one for which they are primarily designed.

TO CARRY OUT further developments and to provide additional working capital for the increased turnover, the directors of Alpha Cement, Ltd., propose that the authorised capital of the company be increased from £1,650,000 to £1,902,500 by the creation of 152,000 new 5½ per cent. cumulative preference shares of £1 each, and 100,000 new ordinary shares of £1 each. In addition, the existing debenture stockholders will be asked to give their consent to a further issue of £200,000 4½ per cent. first mortgage debenture stock. The directors recently decided to install an additional kiln at the Metropolitan works, to increase the operating capacity of that plant from 250,000 tons per annum to approximately 375,000 tons per annum, in order to obtain the utmost benefit from the close proximity of the plant to the London area where so large a proportion of the cement of this country is consumed. The work is already well in hand. It was also decided to replace one of the old kilns acquired with the Thames works by one of the most modern type. It is expected that this work will be completed early next year. Improvements are also being carried out at the Oxford, Rodmell and Kirton-Lindsey works.

THE NOMINAL CAPITAL of the British Oxygen Co., Ltd., has been increased by the addition of £500,000 in £1 ordinary shares beyond the registered capital of £3,500,000.

THE JAPANESE OIL FEDERATION has decided to control the distribution of petrol in Japan through an arrangement with the various oil companies. The Oil Federation recently succeeded in standardising petrol in Japan.

THE NEW PREMISES of the Covent Garden Laboratory, 9 to 13 Kean Street, W.C., will be opened on Monday afternoon by Sir Frank Smith, secretary of the Department of Scientific and Industrial Research.

IN HIS REVIEW at Wednesday's meeting of Lovering China Clays, Mr. John Lawson, the chairman, said that despite difficulties besetting international business the china clay trade had shown some considerable recovery in the past year, although increased costs in a number of directions had affected the profit margin obtainable. It must be borne in mind that china clay was essentially an exported commodity, and factors necessary for world trade recovery had an important influence on the company's business.

MR. M. G. LIVERMAN, chairman, announced at Wednesday's meeting of Lancegaye Safety Glass (1934) that owing to the success of Lancegaye in this country great interest had been shown in the Dominions and foreign countries in the company's safety glass, and negotiations were pending for the sale of the rights of its patents and secret processes. Arrangements had been completed in the Irish Free State for the formation of Lancegaye Safety Glass (Ireland), to commence manufacturing safety glass in that country.

A DEPUTATION from the Federation of British Industries, introduced by Mr. Bernard Docker in the absence of Lord Hirst, president, was received at the Board of Trade on June 18, by Mr. Oliver Stanley, President of the Board of Trade, who was accompanied by Mr. R. S. Hudson, Secretary to the Department of Overseas Trade. The deputation laid before Mr. Stanley the views of the Federation on United Kingdom trade with India, with particular reference to the forthcoming negotiations with the Government of India on the subject of the trade agreement between the United Kingdom and India. Mr. Stanley undertook that the fullest consideration would be given to the Federation's representations.

THE TREASURY, on the recommendation of the Import Duties Advisory Committee, has made the Import Duties (Exemptions) (No. 9) Order, 1937, which provides for the addition to the free list as from June 24, 1937, of ferro-silicon containing not less than 20 per cent. of silicon. Ferro-silicon containing not less than 35 per cent. of silicon is already exempt from duty under Section 14 of the Finance Act, 1933. There is, however, no manufacture in this country of ferro-silicon containing 20 per cent. or more of silicon, and the committee considers that it will be of some assistance to the iron and steel industry if the existing duty is removed from the lower grades. At the same time it considers that, with a view to avoiding undue complication of the free list, the higher grades of ferro-silicon should also be added to the first schedule to the Import Duties Act.

MR. JUSTICE PORTER, in the King's Bench Division on Wednesday, held that there was no evidence to go to the jury in the action brought by British Celanese, Ltd., against Courtaulds, Ltd., and Dr. Walter Hamis Glover, manager of Courtaulds' research department. He dismissed the action against both defendants with costs. The case lasted eight days. British Celanese alleged that Courtaulds and Dr. Glover had conspired to give false evidence in an action in 1935 by British Celanese against the British Acetate Silk Corp., Ltd., of Stowmarket, and that Courtaulds "maintained" the Stowmarket company. Disposing of the first charge, Mr. Justice Porter held that the action of the Courtauld company in defending their own interests in the 1935 claim was perfectly legitimate. Regarding the allegation of conspiracy, he could see nothing which in any way indicated that the directors of Courtaulds knew, or had reason to suspect, the evidence. Then there was the final point whether there was any cause of action against either the company or Dr. Glover for the "fraudulent giving of evidence intending to induce the court to give a wrong decision." There was no such evidence, and accordingly the action against both defendants would be dismissed, with costs.

Commercial Intelligence

Receiverships

LIVERPOOL CHEMICAL PRODUCTS CO., LTD., Bull Lane, Aintree, Liverpool. (lt., 26/6/37.) Mr. S. Colvin, of 515 Martin's Bank Buildings, Water Street, Liverpool, was appointed receiver and manager on June 15, 1937, under powers contained in debenture dated June 21, 1935.

Inventions in the Chemical Industry

THE following information is prepared from the Official Patents Journal. Printed copies of Specifications accepted may be obtained from the Patent Office, 25 Southampton Buildings, London, W.C.2, at 1s. each. The numbers given under "Applications for Patents" are for reference in all correspondence up to the acceptance of the Complete Specification.

Specifications Open to Public Inspection

COMPOSITIONS CONTAINING RUBBER.—Standard Oil Development Co. Dec. 13, 1935. 28305/36.
PROCESS FOR MAKING POLYVINYL ACETAL RESINS.—Carbide and Carbon Chemicals Corporation. Dec. 14, 1935. 30756/36.
MANUFACTURE OF PERCHLORETHYLENE.—Dr. A. Wacker Ges. Fur Electrochemische Industrie. Dec. 12, 1935. 32012/36.
REFRACTORY COMPOSITION and process for making the same.—Union Carbide and Carbon Research Laboratories, Inc. Dec. 11, 1935. 32662/36.
PROCESS FOR THE CATALYTIC DEHYDROGENATION OF ALIPHATIC HYDROCARBONS.—Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij. Dec. 9, 1935. 33373/36.
MANUFACTURE OF ORGANIC ESTERS.—E. I. du Pont de Nemours and Co. Dec. 13, 1935. 33603/36.
MANUFACTURE OF ORGANIC ACIDS.—E. I. du Pont de Nemours and Co. Dec. 13, 1935. 33700/36.
TREATMENT OF SUPERPHOSPHATE.—Davison Chemical Corporation. Dec. 11, 1935. 33701/36.
PROCESS FOR THE CATALYTIC CONVERSION OF OXIDES OF CARBON into higher hydrocarbons by means of hydrogen.—Ruhrchemie, A.-G. Dec. 10, 1935. 33814/36.
HYDRATION OF OLEFINS.—E. I. du Pont de Nemours and Co. Dec. 13, 1935. 33871/36.
ORGANIC PROCESSES employing boron-halogen-containing compounds.—E. I. du Pont de Nemours and Co. Dec. 13, 1935. 33976/36.
SEPARATION OF THE CONSTITUENTS OF ORGANIC-INORGANIC ADDITION COMPOUNDS.—E. I. du Pont de Nemours and Co. Dec. 13, 1935. 34131/36.
SEPARATION OF THE CONSTITUENTS OF ORGANIC-INORGANIC COMPLEXES.—E. I. du Pont de Nemours and Co. Dec. 13, 1935. 34132/36.
PROCESS AND APPARATUS FOR THE ELECTRO-DEPOSITION OF METALS. A. Cremer. Dec. 12, 1935. (Cognate Application, 34135/36.) 34134/36.

Specifications Accepted with Date of Application

PROCESS FOR RENDERING COMMERCIALY USEFUL THE GASOL AND ETHYLENE contained in industrial gases.—Ruhrchemie, A.-G. Sept. 5, 1934. 467,032.
PROCESS FOR THE MANUFACTURE OF DERIVATIVES OF 3, 17-DIOLS of the cyclopentano polyhydrophenanthrene series.—W. P. Williams. Sept. 9, 1935. 467,161.
ALKALINE-EARTH METAL DOUBLE SALTS OF ORGANIC ACIDS.—Seydel Chemical Co. Oct. 11, 1934. (Samples furnished.) 467,080.
MANUFACTURE OF DYESTUFFS.—Soc. of Chemical Industry in Basle. Nov. 8, 1934. (Cognate Application, 30440/35.) 466,886.
MANUFACTURE AND PRODUCTION OF INTERPOLYMERISATION PRODUCTS.—G. W. Johnson (I. G. Farbenindustrie.) Nov. 8, 1935. 467,084.
PROCESS OF IMPARTING HYDROPHOBIC PROPERTIES TO CELLULOSE FIBRES.—W. W. Groves (I. G. Farbenindustrie.) Nov. 8, 1935. 467,166.
MANUFACTURE AND PRODUCTION OF POLYMERISATION PRODUCTS.—G. W. Johnson (I. G. Farbenindustrie.) Nov. 11, 1935. 467,167.
MANUFACTURE OF INDULINES.—W. W. Groves (J. R. Geigy, A.-G.). Nov. 11, 1935. 467,085.
PRODUCTION OF GLYCOL DERIVATIVES.—Distillers Co., Ltd., H. M. Stanley, and J. E. Youell. Dec. 3, 1935. 467,228.
PRODUCTION OF ICE.—A. Carpmal (I. G. Farbenindustrie.) Dec. 6, 1935. 466,955.
PROCESS FOR THE MANUFACTURE OF β -KETO-ACETALS.—A. Carpmal (I. G. Farbenindustrie.) Dec. 7, 1935. 466,890.
PROCESS FOR THE MANUFACTURE OF CHLORINATED ETHYLKETONES and chlorinated vinylketones.—A. Carpmal (I. G. Farbenindustrie.) Dec. 7, 1935. 466,891.
HIGH-VACUUM DISTILLATION.—R. G. J. Fraser and Imperial Chemical Industries, Ltd. Dec. 9, 1935. 467,028.
FIRE-EXTINGUISHING APPARATUS.—National Fire Protection Co., Ltd., and R. A. Denne. Dec. 10, 1935. 467,101.
PRODUCTION OF OIL-SOLUBLE RESINS.—Bakelite, Ltd. Dec. 11, 1934. 467,234.
PRODUCTION OF PHENOL-ALDEHYDE SYNTHETIC RESINS.—Bakelite, Ltd. Dec. 11, 1934. 467,112.
PROCESS FOR THE MANUFACTURE OF ALKALI METAL HYDROXIDES.—I. L. Clifford and Imperial Chemical Industries, Ltd. Dec. 13, 1935. 467,209.
MANUFACTURE OF 2:4:6-TRIAMINO-1:3:5-TRIAZINE.—A. G. Bloxam (Soc. of Chemical Industry in Basle). Dec. 17, 1935. 466,957.
CLEANING, WETTING, AND DISPERSING AGENTS and the production and use thereof.—A. Beyer. Dec. 17, 1934. 467,035.
MANUFACTURE OF QUATERNARY NITROGEN COMPOUNDS.—W. W. Groves (I. G. Farbenindustrie.) Dec. 18, 1935. 467,244.

MANUFACTURE AND PRODUCTION OF INTERPOLYMERISATION PRODUCTS.—G. W. Johnson (I. G. Farbenindustrie.) Dec. 18, 1935. 466,898.
TREATMENT OF GASES CONTAINING ORGANIC VAPOURS.—Celluloid Corporation. Feb. 11, 1935. 466,910.
MANUFACTURE OF VAT DYESTUFFS and intermediates.—A. G. Bloxam (Soc. of Chemical Industry in Basle). Feb. 13, 1936. 466,968.
PROCESSES FOR REFINING HYDROCARBON OILS.—Edeleanu Ges. 466,977, 466,978, 466,979, 466,980.
MANUFACTURE OF MONOAZO DYESTUFFS.—I. G. Farbenindustrie. Aug. 2, 1935. 467,053.
STABILISING PETROLEUM HYDROCARBONS and method of preparing the same.—Wingfoot Corporation. Sept. 6, 1935. 467,056.
MANUFACTURE AND PRODUCTION OF HIGH-QUALITY LUBRICATING OILS.—I. G. Farbenindustrie. Aug. 17, 1935. 466,996.
PROCESS FOR THE MANUFACTURE OF STABLE CALCIUM THIOSULPHATE SOLUTIONS.—Schering-Kahlbaum, A.-G. Sept. 14, 1935. 467,139.
ELECTROLYTIC PRODUCTION OF ALYALINE LYES and sulphuric acid. I. G. Farbenindustrie. Feb. 20, 1936. 466,946.
PRODUCTION OF CALCINED PHOSPHATES.—Kali-Chemie, A.-G. Feb. 10, 1936. 467,075.
MANUFACTURE AND PRODUCTION OF VAT DYESTUFFS of the anthraquinone series.—G. W. Johnson (I. G. Farbenindustrie.) Dec. 6, 1935. 467,157.

Applications for Patents

SEPARATION OF PARAFFIN from paraffin-containing hydrocarbon mixtures.—Edeleanu-Ges. (United States, May 28.) (Cognate with 15883.) 15884.
PRODUCTION OF METAL PHOSPHATES.—H. D. Elkington. (Kerschbaum.) 15633.
MANUFACTURE OF HYDRIDES of the alkali earth metals.—D. Gardner. 15705.
MANUFACTURE OF CARBIDES of the alkali earth metals.—D. Gardner. 15706.
MANUFACTURE OF EMULSIONS, ETC., from vegetable oils.—R. E. Goldsbrough. 15811.
ELECTRODYNAMIC CONDENSER APPARATUS.—E. H. Greibach. (United States, June 10, '36.) 15780.
MANUFACTURE OF SOLUTIONS OF HIGHLY POLYMERIC SUBSTANCES. W. W. Groves (I. G. Farbenindustrie.) 15425.
CELLULOSE ESTERS.—W. W. Groves. 15721.
DEVICE FOR DETERMINING THE ANALYTICAL DATA OF MINERAL OILS. R. Heinze. (Germany, June 6, '36.) 15654.
DEVICE FOR DETERMINING THE ANALYTICAL DATA OF MINERAL OILS.—R. Heinze. (Germany, Dec. 14, '36.) 15655.
ANTHRAQUINONE DYESTUFFS.—R. N. Heslop. 16045.
DEGREASING OF NON-ABSORBENT ARTICLES.—N. R. Hood, L. Hargreaves, and Imperial Chemical Industries, Ltd. 15893.
PIGMENT PASTES.—I. G. Farbenindustrie. (Germany, June 5, '36.) 15426.
PRODUCTION OF VALUABLE HYDROCARBONS, ETC., from carbon monoxide and hydrogen.—I. G. Farbenindustrie. 15439.
MANUFACTURE OF PIGMENTS.—I. G. Farbenindustrie. (Germany, July 16, '36.) 15748.
MANUFACTURE OF VAT DYESTUFFS of the dipyrazolanthronone series.—I. G. Farbenindustrie. (Germany, June 9, '36.) 15767.
ANTHRAQUINONE DYESTUFFS.—Imperial Chemical Industries, Ltd., and W. W. Tatum. 16045.
MANUFACTURE OF AROMATIC OXYKETONE ARSENICALS.—L. Mellersh-Jackson (Parke, Davis and Co.). 15558.
MANUFACTURE OF SYNTHETIC RESINS.—G. W. Johnson (I. G. Farbenindustrie.) 15744.
HALOGENATION OF DERIVATIVES OF BENZOIC ACID.—G. W. Johnson. 15745, 15862.
MANUFACTURE OF COPPER PHTHALOCYANINE.—G. W. Johnson. 15863, 15864.
MANUFACTURE OF OXIDES OF NITROGEN.—G. W. Johnson. 15865.
MANUFACTURE OF DYESTUFFS.—G. W. Johnson. 15866.
BREAKING OF MINERAL OIL EMULSIONS.—G. W. Johnson. 15867.
DYEING, ETC., OF CELLULOSE ESTERS and ethers.—G. W. Johnson. 16062.
PRODUCTION OF ACTIVE CARBON.—J. C. Liddle. 15435.
APPARATUS FOR VAPORISING METALS, ETC.—R. Maier. (Germany, June 8, '36.) 15910.
APPARATUS FOR VAPORISING METALS, ETC.—R. Maier. (Germany, June 16, '36.) 15911.
PROCESS OF TREATING FIBROUS MATERIALS.—Naamlooze Vennootschap Chemische Fabriek Servo, and M. D. Rozenbroek. (April 15, '36.) 15746.
METHOD OF PREPARING LAYERS OF ALKALINE EARTH CARBONATES.—Naamlooze Vennootschap Philips' Gloeilampenfabrieken. (Germany, June 12, '36.) 15991.

- APPARATUS FOR VAPORISING METALS.—R. Maier. (Germany, June 19, '36.) 15912.
- APPARATUS FOR THE PRODUCTION OF OCTONE-RICH BENZENES and aromatic hydrocarbons.—A. Mironescu, and J. Niculescu. 15915.
- TREATMENT OF BLEACHING CLAYS, ETC.—Noble and Thörl Ges., and G. Stalman. 15994.
- MANUFACTURE OF A BORON CARBIDE ALLOY.—Norton Grinding Wheel Co., Ltd. (United States, June 10, '36.) 15515, 15516.
- LOW AND MEDIUM TEMPERATURE CARBONISATION PROCESSES and apparatus.—F. Puening. 16032, 16033.
- MANUFACTURE OF COMPLEX GOLD COMPOUNDS of albumose-like keratin degradation products containing sulphhydryl groups.—Schering-Kahlbaum, A.-G. (Germany, June 12, '36.) 16004.
- MANUFACTURE OF COMPLEX GOLD COMPOUNDS of albumose-like keratin degradation products containing sulphhydryl groups.—Schering-Kahlbaum, A.-G. (Germany, July 21, '36.) (Cognate with 16004.) 16005.
- PROCESS FOR OBTAINING BERYLLIUM.—Seri Holding Soc. Anon. (Italy, June 5, '36.) 15761.
- PROCESS FOR OBTAINING BERYLLIUM.—Seri Holding Soc. Anon. (Italy, Dec. 19, '36.) (Cognate with 15761.) 15762, 15763.
- PROCESS FOR OBTAINING BERYLLIUM.—Seri Holding Soc. Anon. (Italy, April 29.) (Cognate with 15761.) 15764, 15765.
- PREPARATION OF ALKALINE NITRATES.—Soc. d'Etudes pour la Fabrication et l'Emploi des Engrais Chimiques. (France, June 5, '36.) 15556.
- PREPARATION OF POTASSIUM NITRATE.—Soc. d'Etudes pour la Fabrication et l'Emploi des Engrais Chimiques. (France, June 8, '36.) 15557.
- RECOVERY OF HYDROCARBONS.—W. A. A. Thiemann (Carbo-Norit-Union Verwaltungs-Ges.). 15747.
- METHODS OF PURIFYING TITANIUM SULPHATE SOLUTIONS.—United Color and Pigment Co., Inc. (United States, June 16, '36.) 15859, 15861.
- MANUFACTURE OF 4:4' DINITRODIPHENYLSULPHIDE.—Wellcome Foundation, Ltd. 15389.
- COLOURATION OF TEXTILE MATERIALS.—J. Allan, J. A. Wainwright, and R. T. Wrathall. 16740.
- MANUFACTURE OF HYDROXY AMINO COMPOUNDS.—H. H. Bassford and Belvedere Chemical Co., Ltd. 16116.
- ANTI-OXIDANTS.—Belvedere Chemical Co., Ltd., and L. H. Howland. 16115.
- MANUFACTURE OF KETOLS, ETC.—A. G. Bloxam (Soc. of Chemical Industry in Basle.) 16469.
- MANUFACTURE OF UNSATURATED 3-KETONES of the sexual hormone series.—A. G. Bloxam (Soc. of Chemical Industry in Basle.) 16594.
- MANUFACTURE OF ALCOHOLS or their derivatives of the sexual hormone series.—A. G. Bloxam (Soc. of Chemical Industry in Basle.) 16767.
- AUTOMATIC ARRANGEMENT FOR RECUPERATION BY SOLID ADSORBENTS.—Carbonisation et Charbons Actifs. (France, March 10.) 16119.
- APPARATUS FOR DIFFUSING GASES IN LIQUIDS.—British Thomson-Houston Co., Ltd. (Allgemeine Electricitäts-Ges.). 16376.
- MANUFACTURE OF LEUCO ESTERS of vattable compounds.—A. Carpmal (I. G. Farbenindustrie.) 16287.
- MANUFACTURE OF DYESTUFFS of the phthalocyanine series.—A. Carpmal (I. G. Farbenindustrie.) 16384.
- CHLORINE DERIVATIVES OF ETHYLBENZENE.—O. W. Cass, and E. I. du Pont de Nemours and Co., and A. A. Levine. 16665.
- ISOPROPYL DERIVATIVES OF DIPHENYL.—O. W. Cass. 16668.
- DYEING, ETC., OF VAT AND SULPHUR DYESTUFFS.—Chemical Works, formerly Sandoz. (Switzerland, June 15, '36.) 16647.
- MANUFACTURE OF DYESTUFFS of the anthraquinone series.—Chemical Works, formerly Sandoz. (Switzerland, June 18, '36.) 16787.
- ARYLAMINOANTHRAQUINONE COMPOUNDS.—S. Coffey, Imperial Chemical Industries, Ltd., and F. Lodge. 16318.
- PROCESS OF DYEING FURS.—Compagnie Nationale de Matieres Colorantes et Manufactures de Produits Chimiques du Nord Reunies Etablissements Kuhlmann. (France, June 16, '36.) 16197.
- RECOVERY OF SULPHURETTED HYDROGEN, ETC., FROM GASES.—De Directie van de Staatsmijnen in Limburg, and Dr. C. Otto and Co., Ges. (Germany, June 12, '36.) 16454.
- RECOVERY OF SULPHURETTED HYDROGEN, ETC., FROM GASES.—De Directie van de Staatsmijnen in Limburg, and Dr. C. Otto and Co., Ges. (Germany, Sept. 30, '36.) 16455.
- HETEROCYCLIC COMPOUNDS.—C. E. Dent, and Imperial Chemical Industries, Ltd. 16497.
- PRODUCTION OF MONO-ALKYLOLAMINES, ETC.—H. D. Elkington (Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij). 16489.
- METHOD OF DEHYDRATING YEAST.—E. Färber, and Naamlooze Vennootschap Internationale Suiker en Alcohol Cie. 16397.
- MANUFACTURE OF MONO-CHLORONAPHTHALENE.—W. W. Groves. (Germany, June 13, '36.) 16453.
- MANUFACTURE OF POLYMERISATION PRODUCTS.—W. W. Groves. (I. G. Farbenindustrie.) 16141.
- MANUFACTURE OF AFTER-CHROMABLE ACID DYESTUFFS of the triphenylmethane series.—W. W. Groves. 16250.
- MANUFACTURE OF ARTIFICIAL SUBSTANCES containing nitrogen.—W. W. Groves. 16251.
- MANUFACTURE OF CELLULOSIC STAPLE FIBRES.—W. W. Groves. 16254.
- MANUFACTURE OF STABLE SOLUTIONS OF ASCORBIC ACID SALTS OF HISTIDINE.—F. Hoffman-La Roche and Co., A.-G. (Switzerland, July 9, '36.) 16760.
- MANUFACTURE OF DERIVATIVES of the cyclopentanopolyhydrophenanthrene.—I. G. Farbenindustrie. (Germany, June 11, '36.) 16137.
- PROCESS FOR HARDENING ALBUMINOUS SUBSTANCES.—I. G. Farbenindustrie. (Germany, July 28, '36.) 16138.
- MANUFACTURE OF SOLUTIONS OF CELLULOSE IN SULPHURIC ACID. I. G. Farbenindustrie. (Germany, July 21, '36.) 16593.

Chemical and Allied Stocks and Shares

THE continued absence of activity in the industrial and other markets of the Stock Exchange this week has been attributed to increased uncertainty regarding political conditions on the Continent. The general trend was for prices to move against holders, but shares of most chemical and kindred companies were relatively well maintained on balance for the week. Imperial Chemical are 37s. at the time of writing, the same as last week. British Oxygen and Mexco did not keep best prices but were reported to be more active, while Associated Portland Cement and British Plaster Board at 90s. 7½d. and 38s. 7½d. respectively are moderately higher on balance, despite renewed talk of a sharp reduction of activity in the building trades later in the year. Wall Paper deferred were again favoured on account of the good yield offered and market anticipations that the dividend is again likely to be brought up to 12½ per cent.

Boots Pure Drug at 50s. 9d. are little changed. In view of the large reserves and general strength of the balance sheet it continues to be felt in the market that sooner or later some form of bonus is likely to be distributed to shareholders. General Electric is another company concerning which similar anticipations are being entertained, but at 79s. the price has shown very little response, although there is vague talk of a possible offer of additional shares to shareholders on bonus terms. Sangers made the lower price of 26s. 10½d., but are now "ex" the recently-declared dividend. Timothy Whites and Taylors improved 9d. to 33s. aided by the belief expressed in the market that profits are probably benefiting more fully from the amalgamation represented by the company and that there seems a reasonable possibility of a larger dividend. Although "ex" the interim dividend, Turner and Newall at 90s. show an improvement of a few pence on balance. Lever Bros. preference were little changed and British Oil and Cake Mills preferred were reported to be firmer. United Premier Oil and Cake ordinary were more active and transferred around

the rather better level of 9s. 3d. This is another case where an apparently favourable yield is offered, but the company's results may turn a good deal on the trend in prices of fats and oils.

Pinchin Johnson, International Paint and other paint shares were rather neglected but have been quite well maintained in price. The assumption in the market is that most paint companies are probably earning increased profits, and that although there may be no change in the interim dividends, prospects of larger final dividends are considered to be promising.

Barry and Staines Linoleum were reactionary, having declined on balance for the week from 45s. to 44s., while Michael Nairn and Greenwich are 68s. 9d., or 1s. 3d. below the price current a week ago. Triplex Safety Glass have been in better demand on a wider realisation of the favourable dividend estimates current in the market, and as compared with a week ago the price has improved from 65s. 7½d. to 67s. 6d. Lancegaye Safety Glass continued active on further consideration of the past year's results, but were virtually unchanged in price.

Stanton Ironworks were better in view of the large margin of earnings over the 10 per cent. dividend shown by the full results. Staveley Coal and Iron were assisted by continued hopes of a larger dividend and Dorman Long and Consett Iron were also better.

Bleachers' ordinary and preference remained dull despite the improved results published recently. Calico Printers' issues were dull, although there are hopes that later in the year this company may also be able to make a payment on account of preference dividend arrears. Lancashire Cotton Corporation ordinary failed to keep all the improvement which followed the recent publication of the profit figures for the first half of the financial year.

Oil shares were again neglected and lower on balance, but this was attributed to general market conditions and not to any less favourable views as to the outlook for the industry.

Weekly Prices of British Chemical Products

THERE are no price changes to report this week in the London market for chemical products. Unless otherwise stated, the prices below cover fair quantities net and naked at sellers' works.

MANCHESTER.—Although actual new business on the Manchester chemical market during the past week has been on no more than a moderate scale both in respect of new contract bookings and of near delivery transactions, sellers mostly report a steady flow of specifications against old commitments, with the movement of textile chemicals into consumption about maintained at the recently improved level. Prices generally are well held and in the case of the lead products these are still on offer at around last week's reduced levels, with relatively little change on balance in the other non-ferrous metal compounds. Good quantities of by-products are being called for against contracts, also fresh bookings continue on the quiet side. Values, however, are firm pretty well throughout the range.

General Chemicals

ACETONE.—£45 to £47 per ton.
ACID, ACETIC.—Tech., 80%, £30 5s. to £32 5s. per ton; pure 80%, £30 5s.; tech., 40%, £15 12s. 6d. to £18 12s. 6d.; tech., 60%, £23 10s. to £25 10s. **MANCHESTER:** 80%, commercial, £30 5s.; tech. glacial, £42 to £46.
ACID, BORIC.—Commercial granulated, £28 10s. per ton; crystal, £29 10s.; powdered, £30 10s.; extra finely powdered, £32 10s. in 1-cwt. bags, carriage paid home to buyers' premises within the United Kingdom in 1-ton lots. **GLASGOW:** Crystals, £29 10s.; powdered, £30 10s. 1-cwt. bags in 1-ton lots.
ACID, CHROMIC.—91d. per lb., less 2½%; d/d U.K.
ACID, CITRIC.—1s. per lb. **MANCHESTER:** 1s. **SCOTLAND:** B.P. crystals, 1s. per lb., less 5%, ex store.
ACID, FORMIC.—85%, in carboys, ton lots, £42 to £47 per ton.
ACID, HYDROCHLORIC.—Spot, 5s. to 7s. 6d. carboy d/d according to purity, strength and locality.
ACID, LACTIC.—LANCASHIRE: Dark tech., 50% by vol., £24 10s. per ton; 50% by weight, £28 10s.; 80% by weight, £50; pale tech., 50% by vol., £28; 50% by weight, £33; 80% by weight, £55; edible, 50% by vol., £41. One-ton lots ex works, barrels free.
ACID, NITRIC.—80° Tw. spot, £18 to £25 per ton makers' works.
ACID, OXALIC.—£48 15s. to £57 10s. per ton, according to packages and position. **GLASGOW:** £2 9s. per cwt. in casks. **MANCHESTER:** £49 10s. to £55 per ton ex store.
ACID, SULPHURIC.—168° Tw., £4 5s. to £4 15s. per ton; 140° Tw., arsenic-free, £2 15s. to £3 5s.; 140° Tw., arsenious, £2 10s.
ACID, TARTARIC.—1s. 1½d. per lb. less 5%, carriage paid for lots of 5 cwt. and upwards. **MANCHESTER:** 1s. 1½d. per lb.
ALUM.—Loose lump, £8 7s. 6d. per ton d/d; **GLASGOW:** Ground, £10 7s. 6d. per ton; lump, £9 17s. 6d.
ALUMINIUM SULPHATE.—£7 per ton d/d Lanes.; **GLASGOW:** £7 to £8 ex store.
AMMONIA, ANHYDROUS.—Spot, 10d. per lb. d/d in cylinders. **SCOTLAND:** 10d. to 1s. containers extra and returnable.
AMMONIA, LIQUID.—**SCOTLAND:** 80°, 2½d. to 3d. per lb., d/d.
AMMONIUM BICHROMATE.—8d. per lb. d/d U.K.
AMMONIUM CARBONATE.—£20 per ton d/d in 5 cwt. casks.
AMMONIUM CHLORIDE.—LONDON: Fine white crystals, £16 10s. (See also Salammoniac.)
AMMONIUM CHLORIDE (MURIATE).—**SCOTLAND:** British dog tooth crystals, £32 to £35 per ton carriage paid according to quantity. (See also Salammoniac.)
ANTIMONY OXIDE.—£55 10s. per ton.
ARSENIC.—LONDON: £13 10s. per ton c.i.f. main U.K. ports for imported material; Cornish nominal, £22 10s. f.o.r. mines. **SCOTLAND:** White powdered, £17 ex store. **MANCHESTER:** White powdered Cornish, £17, ex store.
BARIUM CHLORIDE.—£10 per ton. **GLASGOW:** £11 5s. per ton.
BISULPHITE OF LIME.—£6 10s. per ton f.o.r. London.
BLEACHING POWDER.—Spot, 35/37%, £8 15s. per ton in casks, special terms for contracts. **SCOTLAND:** £9 per ton net ex store.
BORAX COMMERCIAL.—Granulated, £16 per ton; crystal, £17; powdered, £17 10s.; extra finely powdered, £18 10s., packed in 1-cwt. bags, carriage paid home to buyers' premises within the United Kingdom in 1-ton lots. **GLASGOW:** Granulated, £16, crystal, £17; powdered, £17 10s. per ton in 1-cwt. bags, carriage paid.
CALCIUM CHLORIDE.—Solid 70/75% spot, £5 5s. per ton d/d station in drums. **GLASGOW:** 70/75% solid, £5 10s. per ton net ex store.
CHROMETAN.—Crystals, 2½d. per lb.; liquor, £19 10s. per ton d/d
CREAM OF TARTAR.—£3 19s. per cwt. less 2½%. **GLASGOW:** 99%, £4 7s. per cwt. in 5-cwt. casks.
FORMALDEHYDE.—£22 10s. per ton.
GLYCERINE.—Chemically pure, double distilled, 1.260 s.g., in tins, £5 7s. 6d. to £6 7s. 6d. per cwt. according to quantity; in drums, £5 to £5 13s. 6d.

GLASGOW.—There has been a rather better demand for chemicals for home trade during the week, though export business still remains very quiet. Prices generally continue quite steady at about previous figures, one or two articles being rather dearer, but lead products are lower on account of the further fall in the price of the metal. In the coal tar products group trading conditions during the week have been fairly steady. Carbolic acid 60's is in particularly strong demand and available supplies are likely to remain limited over some months to come. Cresylic acid is rather less active and a few spot lots have been on the market at a discount on values quoted. This is generally regarded as a temporary phase, however, and local manufacturers' prices meantime continue very firm. Motor benzol values are very stable round 1s. 5d. per gallon f.o.r. makers' works. Fresh quantities have been offered at this figure during the week, although in the main supplies are fairly well covered by current contracts.

IODINE.—Resublimed B.P., 5s. 1d. per lb.
LEAD ACETATE.—LONDON: White, £35 10s. per ton; brown, £35. **GLASGOW:** White crystals, £34 to £35; brown, £1 per ton less. **MANCHESTER:** White, £36; brown, £35 10s.
LEAD NITRATE.—£39 per ton.
LEAD, RED.—**SCOTLAND:** £35 per ton, less 2½%, carriage paid for 2-ton lots.
LEAD (WHITE SUGAR OF).—**GLASGOW:** £36 per ton net, ex store.
LITHARGE.—**SCOTLAND:** Ground, £37 per ton, less 2½%, carriage paid for 2-ton lots.
MAGNESITE.—**SCOTLAND:** Ground calcined, £9 per ton, ex store.
MAGNESIUM CHLORIDE.—**SCOTLAND:** £7 10s. per ton.
MAGNESIUM SULPHATE.—Commercial, £5 per ton, ex wharf.
MERCURY.—Ammoniated B.P. (white precip.), lump, 5s. 11d. per lb.; powder B.P., 6s. 1d.; bichloride B.P. (corros. sub.) 5s. 2d.; powder B.P. 4s. 10d.; chloride B.P. (calomel), 5s. 11d.; red oxide cryst. (red precip.), 7s.; levig. 6s. 6d.; yellow oxide B.P. 6s. 4d.; persulphate white B.P.C., 6s. 1d.; sulphide black (hyd. sulph. cum sulph. 50%), 6s. For quantities under 112 lb., 1d. extra.
METHYLATED SPIRIT.—61 O.P. industrial, 1s. 5d. to 2s. per gal.; pyridinised industrial, 1s. 7d. to 2s. 2d.; mineralised, 2s. 6d. to 3s. Spirit 64 O.P. is 1d. more in all cases and the range of prices is according to quantities. **SCOTLAND:** Industrial 64 O.P., 1s. 9d. to 2s. 4d.
PARAFFIN WAX.—**SCOTLAND:** 3½d. per lb.
PHENOL.—7½d. to 8½d. per lb.
POTASH, CAUSTIC.—LONDON: £42 per ton. **MANCHESTER:** £39 10s.
POTASSIUM BICHROMATE.—**SCOTLAND:** 5d. per lb., net, carriage paid.
POTASSIUM CHLORATE.—£36 7s. 6d. per ton. **GLASGOW:** 4½d. per lb. **MANCHESTER:** £38 per ton.
POTASSIUM IODIDE.—B.P. 4s. 3d. per lb.
POTASSIUM NITRATE.—£27 per ton. **GLASGOW:** Refined granulated, £29 per ton c.i.f. U.K. ports. Spot, £30 per ton ex store.
POTASSIUM PERMANGANATE.—LONDON: 9½d. per lb. **SCOTLAND:** B.P. Crystals, 9½d. **MANCHESTER:** B.P. 10½d. to 1s.
POTASSIUM PRUSSATE.—6½d. per lb. **SCOTLAND:** 7d. net, in casks, ex store. **MANCHESTER:** Yellow, 6½d. to 6½d.
SALAMMONIAC.—First lump spot, £41 17s. 6d. per ton d/d in barrels. **GLASGOW:** Large crystals, in casks, £37.
SALT CAKE.—Unground, spot, £3 16s. 6d. per ton.
SODA ASH.—58% spot, £5 12s. 6d. per ton f.o.r. in bags.
SODA, CAUSTIC.—Solid, 76/77° spot, £12 10s. per ton d/d station. **SCOTLAND:** Powdered 98/99%, £17 10s. in drums, £18 5s. in casks, Solid 76/77°, £14 12s. 6d. in drums; 70/73%, £14 12s. 6d., carriage paid buyer's station, minimum 4-ton lots; contracts 10s. per ton less.
SODA CRYSTALS.—Spot, £5 to £5 5s. per ton d/d station or ex depot in 2-cwt. bags.
SODIUM ACETATE.—£18 per ton carriage paid North. **GLASGOW:** £18 10s. per ton net ex store.
SODIUM BICARBONATE.—Refined spot, £10 10s. per ton d/d station in bags. **GLASGOW:** £12 15s. per ton in 1 cwt. kegs, £11 per ton in 2-cwt. bags. **MANCHESTER:** £10 10s.
SODIUM BICHROMATE.—Crystals cake and powder 4d. per lb. net d/d U.K. discount 5%. **MANCHESTER:** 4d. per lb. **GLASGOW:** 4d., net, carriage paid.
SODIUM BISULPHITE POWDER.—60/62%, £20 per ton d/d 1 cwt. iron drums for home trade.
SODIUM CARBONATE, MONOHYDRATE.—£15 per ton d/d in minimum ton lots in 2 cwt. free bags.
SODIUM CHLORATE.—£26 10s. to £30 per ton. **GLASGOW:** £1 10s. per cwt.
SODIUM CHROMATE.—4d. per lb. d/d U.K.
SODIUM HYPOSULPHATE.—Commercial, 2 ton lots d/d, £10 5s. per ton; photographic, £14 5s. **MANCHESTER:** Commercial, £10; photographic, £14 10s.

SODIUM METASILICATE.—£14 per ton, d/d U.K. in cwt. bags.
SODIUM NITRATE.—Refined, £7 15s. per ton for 6-ton lots d/d.
SODIUM NITRITE.—£18 5s. per ton for ton lots.
SODIUM PERBORATE.—10%, 9½d. per lb. d/d in 1-cwt. drums.
SODIUM PHOSPHATE.—£13 per ton.
SODIUM PRUSSIAN.—4d. per lb. for ton lots. GLASGOW: 5d. to 5½d. ex store. MANCHESTER: 4d. to 4½d.
SODIUM SILICATE.—£9 10s. per ton.
SODIUM SULPHATE (GLAUBER SALTS).—£3 per ton d/d.
SODIUM SULPHATE (SALT CAKE).—Unground spot, £3 12s. 6d. per ton d/d station in bulk. SCOTLAND: Ground quality, £3 5s. per ton d/d. MANCHESTER: £3 10s. to £3 15s.
SODIUM SULPHIDE.—Solid 60/62%, Spot, £11 5s. per ton d/d in drums; crystals 30/32%, £8 15s. per ton d/d in casks. MANCHESTER: Concentrated solid, 60/62%, £11; commercial, £8.
SODIUM SULPHITE.—Pea crystals, spot, £13 5s. per ton d/d station in kegs. Commercial spot, £8 15s. d/d station in bags.
SULPHATE OF COPPER.—£20 per ton, less 2%, in casks. MANCHESTER: £22 10s. per ton f.o.b. SCOTLAND: £24 per ton less 5%, Liverpool, in casks.
SULPHUR PRECIP.—B.P., £55 to £60 per ton according to quantity. Commercial, £50 to £55.
ZINC SULPHATE.—Crystals, £9 per ton, f.o.r., in bags.

Rubber Chemicals

ANTIMONY SULPHIDE.—Golden, 6½d. to 1s. 1d. per lb., according to quality. Crimson, 1s. 5½d. to 1s. 7d. per lb., according to quality.
ARSENIC SULPHIDE.—Yellow, 1s. 5d. to 1s. 7d. per lb.
BARYTES.—£6 to £7 10s. per ton, according to quality
CADMIUM SULPHIDE.—7s. 7d. to 8s. per lb.
CARBON BISULPHIDE.—£31 to £33 per ton, according to quantity, drums extra.
CARBON BLACK.—3 11/16d. to 4 13/16d. per lb., ex wharf.
CARBON TETRACHLORIDE.—£41 to £46 per ton, according to quantity, drums extra.
CHROMIUM OXIDE.—Green, 1s. 2d. per lb.
DIPHENYLGUANIDINE.—2s. 2d. per lb.
INDIA-RUBBER SUBSTITUTES.—White, 4½d. to 5d. per lb.; dark, 3½d. to 4½d. per lb.
LAMP BLACK.—£22 to £23 per ton d/d London; vegetable black, £28 to £48.
LEAD HYPOSULPHITE.—9d. per lb.
LITHOPONE.—30%, £16 10s. to £17 5s. per ton.
SULPHUR.—£9 to £9 5s. per ton. SULPHUR PRECIP. R.P., £55 to £60 per ton. SULPHUR PRECIP. COMM., £50 to £55 per ton.
SULPHUR CHLORIDE.—5d. to 7d. per lb., according to quantity.
VERMILION.—Pale, or deep, 5s. 3d. per lb., 1-cwt. lots.
ZINC SULPHIDE.—10d. to 11d. per lb., according to quality.

Nitrogen Fertilisers

SULPHATE OF AMMONIA.—Neutral quality, basis 20.6 per cent. nitrogen, delivered in 6-ton lots to farmer's nearest station, £7 5s. per ton.
CALCIUM CYANAMIDE.—£7 5s. per ton, carriage paid to any railway station in Great Britain in lots of four tons and over.
NITRO-CHALK.—£7 5s. per ton for delivery to end of June.
NITRATE OF SODA.—£7 12s. 6d. per ton for delivery up to end of June.
CONCENTRATED COMPLETE FERTILISERS.—£10 12s. to £11 1s. per ton delivered in 6-ton lots to farmer's nearest station.
AMMONIUM PHOSPHATE FERTILISERS.—£10 5s. to £13 15s. per ton for delivery up to end of June, delivered in 6-ton lots to farmer's nearest station.

Coal Tar Products

ACID, CRESYLIC.—97/99%, 5s. 3d. to 5s. 5d. per gal.; 99/100%, 5s. to 6s., according to specification; pale 99%, 5s. 6d. to 5s. 8d.; dark, 4s. 8d. to 4s. 10d. GLASGOW: Pale, 99/100%, 5s. to 5s. 6d. per gal.; pale 97/99%, 4s. 6d. to 4s. 10d.; dark, 97/99%, 4s. 3d. to 4s. 6d.; high boiling acids, 2s. 4d. to 2s. 8d. American specification, 4s. 3d. to 4s. 6d. MANCHESTER: Pale, 99/100%, 5s. 3d.
ACID, CARBOLIC.—Crystals, 7½d. to 8½d. per lb.; crude, 60's, 4s. 3d. to 4s. 6d. per gal. MANCHESTER: Crystals, 8½d. per lb. f.o.b. in drums; crude, 4s. per gal. GLASGOW: Crude, 60's, 4s. to 4s. 2d. per gal.; distilled, 60's, 4s. 4d. to 4s. 8d.
BENZOL.—At works, crude, 10d. to 10½d. per gal.; standard motor, 1s. 3½d. to 1s. 4d.; 90%, 1s. 4½d. to 1s. 5d.; pure, 1s. 8½d. to 1s. 9d. GLASGOW: Crude, 10d. to 10½d. per gal.; motor, 1s. 5d. to 1s. 5½d.
CREOSOTE.—B.S.I. Specification standard, 6d. per gal. f.o.r. Home, 3½d. d/d. LONDON: 4½d. f.o.r. North: 5d. London. MANCHESTER: 5½d. to 6½d. GLASGOW: B.S.I. Specification, 6d. to 6½d. per gal.; washed oil, 5d. to 5½d.; lower sp. gr. oils, 5½d. to 5¾d.
NAPHTHA.—Solvent, 90/160%, 1s. 7d. to 1s. 8d. per gal.; 95/160%, 1s. 8d. to 1s. 9d.; 90/190%, 1s. 2d. to 1s. 3d. LONDON: Solvent, 1s. 3½d. to 1s. 4d.; heavy, 1½d. to 1s. 0½d. f.o.r. GLASGOW: Crude, 6d. to 6½d. per gal.; 90% 160, 1s. 6½d. to 1s. 7½d., 90% 190, 1s. 1d. to 1s. 2d.

NAPHTHALENE.—Crude, whizzed or hot pressed, £10 10s. to £11 10s. per ton; purified crystals, £18 to £20 per ton in 2-cwt. bags. LONDON: Fire lighter quality, £5 to £5 10s. per ton; crystals, £27 to £27 10s. GLASGOW: Fire lighter, crude, £6 to £7 per ton (bags free). MANCHESTER: Refined, £22 per ton f.o.b.
PYRIDINE.—90/140%, 9s. to 9s. 6d. per gal.; 90/180, 2s. 9d. to 3s. 6d. GLASGOW: 90% 140, 9s. to 10s. per gal.; 90% 160, 7s. to 8s.; 90% 180, 2s. 6d. to 3s.
TOLUOLE.—90%, 2s. 1d. per gal.; pure, 2s. 6d. to 2s. 7d. GLASGOW: 90%, 120, 1s. 10d. to 1s. 11d. per gal.
PITCH.—Medium, soft, 36s. to 37s. per ton, in bulk at makers' works. MANCHESTER: 36s. f.o.b., East Coast. GLASGOW: f.o.b. Glasgow, 32s. to 37s. per ton; in bulk for home trade, 32s. 6d.
XYLOL.—Commercial, 2s. 3d. per gal.; pure, 2s. 5d. GLASGOW: Commercial, 2s. to 2s. 1d. per gal.

Wood Distillation Products

ACETATE OF LIME.—Brown, £8 5s. to £8 15s. per ton; grey, £10 10s. to £11 10s. Liquor, brown, 30° Tw., 6d. to 8d. per gal. MANCHESTER: Brown, £9 10s.; grey, £11 10s.
CHARCOAL.—£6 5s. to £12 per ton, according to grade and locality.
METHYL ACETONE.—40-50%, £42 to £45 per ton.
WOOD CREOSOTE.—Unrefined 6d. to 1s. per gal., according to boiling range.
WOOD, NAPHTHA, MISCIBLE.—2s. 9d. to 3s. 3d. per gal.; solvent, 3s. 6d. to 3s. 9d. per gal.
WOOD TAR.—£3 to £4 per ton.

Intermediates and Dyes

ACID, BENZOIC, 1914 B.P. (ex toluol).—1s. 9½d. per lb. d/d buyer's works.
ACID, GAMMA.—Spot, 4s. per lb. 100% d/d buyer's works.
ACID, H.—Spot, 2s. 4½d. per lb. 100% d/d buyer's works.
ACID NAPHTHIONIC.—1s. 8d. per lb.
ACID, NEVILLE AND WINTHER.—Spot, 3s. per lb. 100%.
ACID, SULPHANILIC.—Spot, 8d. per lb. 100%, d/d buyer's works.
ANILINE OIL.—Spot, 8d. per lb., drums extra, d/d buyer's works.
ANILINE SALTS.—Spot, 8d. per lb. d/d buyer's works, casks free.
BENZIDINE, HCl.—2s. 5d. per lb., 100% as base, in casks.
m-CRESOL 98/100%.—1s. 8d. to 1s. 9d. per lb. in ton lots.
o-CRESOL 30/31° C.—6½d. to 7½d. per lb. in 1-ton lots.
p-CRESOL 34.5° C.—1s. 7d. to 1s. 8d. per lb. in ton lots.
DICHLORANILINE.—1s. 1½d. to 2s. 3d. per lb.
DIMETHYLANILINE.—Spot, 1s. 6d. per lb., package extra.
DINITROBENZENE.—7½d. per lb.
DINITROCHLOROBENZENE, SOLID.—£72 per ton.
DINITROTOLUENE.—48/50° C., 8½d. per lb.; 66/68° C., 10d.
DIPHENYLAMINE.—Spot, 2s. per lb., d/d buyer's works.
α-NAPHTHOL.—Spot, 2s. 4d. per lb., d/d buyer's works.
β-NAPHTHOL.—9½d. to 9½d. per lb.; flake, 9½d. to 9½d.
α-NAPHTHYLAMINE.—Lumps, 1s. per lb.; ground, 1s. 0½d. in casks.
β-NAPHTHYLAMINE.—Spot, 2s. 9d. per lb., d/d buyer's works in casks.
o-NITRANILINE.—3s. 1½d. per lb.
m-NITRANILINE.—Spot, 2s. 7d. per lb., d/d buyer's works.
p-NITRANILINE.—Spot, 1s. 8d. to 2s. 1d. per lb. d/d buyer's works.
NITROBENZENE.—Spot, 4½d. to 5d. per lb., in 90-gal. drums, drums extra. 1-ton lots d/d buyer's works.
NITRONAPHTHALENE.—9d. per lb.; P.G., 1s. 0½d. per lb.
SODIUM NAPHTHIONATE.—Spot, 1s. 9d. per lb., 100% d/d buyer's works.
o-TOLUIDINE.—10½d. per lb., in 8/10-cwt. drums, drums extra.
p-TOLUIDINE.—1s. 10½d. per lb., in casks.
m-XYLIDINE ACETATE.—4s. 3d. per lb., 100%.

Latest Oil Prices

LONDON, June 23.—LINSEED OIL was quiet. Spot, £30 15s. (small quantities); July to Dec., £28 5s.; Jan.-April, £28 7s. 6d., naked. SOYA BEAN OIL was slow. Oriental (bulk), afloat, Rotterdam, £23 15s. RAPE OIL was inactive. Crude extracted, £36; technical refined, £37, naked, ex wharf. COTTON OIL was quiet. Egyptian crude, £27 10s.; refined common edible, £30 15s.; deodorised, £32 15s., naked, ex mill (small lots £1 10s. extra). TURPENTINE was quiet. American, spot, 37s. 6d. per cwt.
HULL.—LINSEED OIL, spot, quoted £29 per ton; June, July-Aug., Sept.-Dec., and Jan.-April, £28 10s. COTTON OIL, Egyptian, crude, spot, £27; edible, refined, spot, £30; technical, spot, £30; deodorised, £32, naked. PALM KERNEL OIL, crude, f.m.q., spot, £25, naked. GROUNDNUT OIL, extracted, spot, £31 10s.; deodorised, £34 10s. RAPE OIL, extracted, spot, £35; refined, £36. SOYA OIL, extracted, spot, £31 10s.; deodorised, £34 10s. per ton. COD OIL, f.o.r. or f.a.s., 27s. 6d. per cwt., in barrels. CASTOR OIL, pharmaceutical, 44s.; first, 39s.; second, 37s. TURPENTINE, American, spot, 39s. per cwt.

New Companies Registered

Keystone Chemical Co., Ltd., Bank Buildings, 16 St. James's Street, S.W.1.—Registered June 21. Nominal capital, £100. Chemical manufacturers, etc. Subscribers:—John T. Key and John R. Turnbull.

L. Hudson Banks, Ltd., 94 High Street, Ruislip, Middlesex.—Registered June 9. Nominal capital, £500. Chemists, druggists, dry salters, etc. Directors: Leopold Hudson Banks, Jessie M. Pugh.

Formosa Preparations, Ltd.—Registered June 18. Capital, £500. Chemists, druggists, drysalters, manufacturers of and dealers in toilet requisites and cosmetics, etc. Subscribers:—Percy Hargrave, The Warren, Hillbury Road, Upper Warrlingham, Surrey; and Emily H. Bradford.

Young and Harrison, Ltd., 7 Gillespie Road, Highbury, N.5.—Registered June 4. Nominal capital, £10,000. Chemists and druggists, manufacturers of, agents for and dealers in drugs, chemicals, toilet preparations, etc. Directors: James C. Young, Alfred W. Harrison.

Glenzair, Ltd., 57-8 Chancery Lane, W.C.2. Registered June 15. Nominal capital £200.—Manufacturers and vendors of air conditioners, purifiers or filters, vaporisers, deodorisers, essences, liquid soap or other chemical products. Directors: Arthur Jackson and Violet Brenda M. Planck.

Galenus, Ltd.—Registered June 17. Nominal capital, £100. Manufacturers of and dealers in chemicals, gases, drugs, plaster of Paris, gypsum, disinfectants, fertilisers, salts, acids, etc. Subscribers:—Albert Fletcher, 38 Wildwood Road, Hampstead, N.W.; and Fdk. W. Bailey.

Chemical and General Development Co., Ltd., 4 Half Moon Street, W.1.—Registered June 17. Nominal capital, £100. To establish and promote companies, to underwrite shares and interests in any company promoted by this company, etc. Directors:—Mrs. Sibyl H. Fitz-Maurice and Colin S. Collen-Smith.

Associated Chemists (Lancashire)—Registered June 10. Nominal capital £10,000. To acquire the business of wholesale and manufacturing chemists recently carried on by J. M. Fairbairn, Ltd., at Fleming House, St. Peter, St. Blackburn. Directors are: Isaac Stout, Wm. H. Stopforth, Samuel Briggs, Walter A. Whorrod.

Deodor-X Co. of England, Ltd., 18 Water Street, Liverpool.—Registered June 16. Nominal capital, £100. Manufacturers of and dealers in chemicals and all or any materials and things used for or connected with the manufacture of chemicals by patent or other process, etc. Subscribers:—Frances J. Langfeld and Harold Rogers.

Bramley Fertilisers and Feeding Stuffs, Ltd., 4 Wormald Row, Albion Street, Leeds, 2.—Registered June 12. Nominal £100. Manufacturers of and dealers in chemical fertilisers, manures, agricultural produce, wool, binder twines, agricultural machinery, etc. Director are: Robt. B. Pearson, Fredk. R. Howard.

North Wales Carbide Company, Ltd., 25 Cross Street, Manchester. Registered June 12. Nominal capital £100. To acquire properties, lands and hereditaments, near Holywell, Flint, including quarries of limestone, limestone for chemical purposes, chert, clay, coal and other minerals, etc. Subscribers: Robert Starkey, secretary, Ralph Noden.

Droitwich Spa (Subsidiary), Ltd.—Registered June 12. Nominal capital of £100,000. Chemists, druggists, dentists and opticians, manufacturers of and dealers in salts, acids, alkalis, drugs, medicines, medicaments, etc. Subscribers: Albert C. Penny, 101 Fore Street, Kingsbridge, Joseph H. Giles, Stafford E. Lidstone, Hedley Furze, Thomas Petter, Cynthia M. Limmer, Mary V. Grogan.

Suncole (Nottingham), Ltd., Surrey House, Victoria Embankment, W.C.2.—Registered June 11. Nominal capital, £30,500. Distillers of coal, cannel, shale and other carbonaceous or carboniferous materials, both experimentally and upon a commercial basis, manufacturers of smokeless fuel, oil and by-products; ironmasters, steel makers and converters, colliery proprietors, manufacturers of chemicals and manures, oil refiners, etc. Directors: Richard D. Hardy, The Duke of Montrose, C.B., C.V.O., Ernest G. Disseker, Col. Dealtry C. Part, Frank J. W. Seely, Robert C. Lancaster.

Manufacturers Overseas Agency, Ltd., 113 High Street, Welling, Kent.—Registered June 9. Nominal capital £500. Manufacturers' representatives, agents, exporters, importers, general merchants, brokers, storekeepers, carriers and contractors, manufacturers of and dealers in Eastern Bazaar goods, iron, steel, copper, lead and other metals, chemicals, medicines, soap, oils, timber, hardware, foodstuffs, tobaccos, cotton, wool, silk and art silk goods, leather and rubber goods, etc. Subscribers are: Leonard H. Butcher, Elsie W. Eady. Directors are Stanley F. Heritage (permanent), Eric F. E. Hodges and Ernest H. C. Heritage.

Lexington Instrument Laboratories, Ltd., 155/157 Great Portland Street, W.1.—Registered June 18. Nominal capital, £100. Manufacturers and vendors of electrical, chemical and mechanical equipment and instruments, etc. Directors:—David Myers, Herbert Wilcox and Roy Cooper.

Books Received

Elasticity, Plasticity, and Structure of Matter. By Dr. R. Houwink. London: Cambridge University Press. 376 pp. 21s.

Thorpe's Dictionary of Applied Chemistry. 4th Edition. Vol. 1. A-Bi. London, New York, and Toronto: Longmans, Green and Co. 703 pp. 63s.

Chemistry, Matter and Life. By Stephen Miall, LL.D., B.Sc., and Laurence Mackenzie Miall, B.A. London: Edward Arnold & Co. Pp. 296. 7s. 6d.

Company News

International Combustion, Ltd.—The directors have declared an interim dividend of 7½ per cent. on the ordinary shares (unchanged), payable on July 15.

Associated Paper Mills.—The directors announce an interim ordinary dividend of 3 per cent. (against 2½ per cent. last year), payable on August 1.

Dortische Petroleum Industrie.—The report for 1936 shows a profit of Fl.6,025,965, against Fl.3,823,195. The total dividend on the ordinary and preference shares is 16.6 per cent., against 10.5 per cent.

Liebig's Extract of Meat.—An interim of 4 per cent., tax free, is announced on the ordinary shares, payable July 8. Last year's interim was also 4 per cent., tax free, and was followed by a final of 6 per cent., tax free.

Solignum.—The report for year ended March 31 shows profit of £7,683 (£6,081); add balance brought forward £333, making £8,016. Preference dividend absorbed £4,920; to tax account £400; to reserve £2,000 (£1,000); forward £696.

United British Oilfields of Trinidad.—The ordinary dividend for 1936 is to be raised from 7½ per cent. to 8½ per cent. The 8 per cent. cumulative participating preference shares will be paid an additional dividend of 3½d. per share for 1936, against 3 4-7 per cent.

Shell Union Oil Corporation.—The directors have declared an interim dividend on the common stock of 50c. per share for 1937, payable on June 15 to holders registered on July 6. Last year dividends were resumed after a lapse of five years with a payment of 25c. per share.

Lobitos Oilfields, Ltd.—The directors recommend a dividend of 10 per cent. and a bonus of 2½ per cent., both less tax at 4s. 9d., for the year ended December 31 last. This compares with payments of 7½ per cent., less tax, for the two preceding years. The authorised and issued capital of the company is £1,000,000.

Anglo-American Oil Co.—A dividend of 5 per cent., against 25 per cent. in 1935, is announced in the report for 1936. Gross profits were £841,216. Income tax for 1936 requires £258,418, leaving a net profit of £582,798. The dividend requires £177,869, and after placing £500,000 to reserve—the first transfer since 1924—the surplus forward is reduced from £569,953 to £474,882.

Venezuelan Oil Concessions.—The accounts for the year ended December 31 last show that after providing £286,314, against £322,991 for depreciation, placing £250,000 against nil to exploration reserve, and deducting drilling, production, field, and other expenses net profits rose from £913,018 to £1,074,068. The directors recommend a final dividend of 15 per cent. on both the ordinary and preference shares, making 22½ per cent. for the 12 months compared with 18½ per cent. for 1935. The carry-forward amounts to £148,085, against £153,623 brought in.

Chemical Trade Inquiries

The following trade inquiries are abstracted from the "Board of Trade Journal." Names and addresses may be obtained from the Department of Overseas Trade (Development and Intelligence), 35 Old Queen Street, London, S.W.1 (quote reference number).

British India.—A firm of merchants and agents established at Bombay wishes to obtain the representation, on a purchasing basis, of United Kingdom manufacturers of refrigerators. (Ref. No. 247.)

Belgium.—An agent established at Grammont (Eastern Flanders) wishes to obtain the sole representation for Belgium or the Flanders area only of United Kingdom manufacturers of aniline dyes and specialities for dyers and other textile works. He desires to work on a basis of commission plus expenses. (Ref. No. 252.)

Metallurgical Section

January 2nd, 1937

Non-Metallic Inclusions in Steel

THERE are two main difficulties in the determination of non-metallic inclusions in steel. First, there is the complex nature and the numerous possible combinations of the oxidic substances; secondly, the variation in character of these inclusions from steel to steel. In the light of present knowledge the value of any selected method cannot be assessed with certainty. Only by the closest co-ordination of metallurgical experience will the problem of the determination of the amount and the identification of the chemical combination of non-metallic inclusions be solved. Crystallography and X-ray analysis might prove to be of value in establishing the existence of certain definite compounds, particularly in the examination of steel-melting slags, and of the non-metallic residues extracted from the resulting metals. Brief investigation along these lines, however, has shown that MnS is not wholly soluble and that Fe_3P is almost completely insoluble in iodine solutions.

Of the methods dealt with in a joint paper which E. W. Colbeck, S. W. Craven and W. Murray read before the Iron and Steel Institute, September 1936, those depending on solutions in an acid were regarded as being of little value. The total oxygen content of plain carbon steels as determined by the iodine method and the chlorine method at 300°C . were in fair agreement, but whilst the figures for Al_2O_3 were comparable, the values for SiO_2 were higher and those for FeO and MnO were lower by the chlorine method. In the chlorine method, moreover, if the reaction temperature was raised from 300° to 500°C ., there was a decrease in the recovery of oxidic inclusions.

Because of the presence of insoluble carbides, it is not possible to determine the non-metallic inclusions in alloy steels by the iodine method, but it is possible to do this by the chlorine method. Steels of the 6 per cent. chromium 0.3 per cent. molybdenum, the 14 per cent. chromium, and the 18 per cent. chromium 8 per cent. nickel types were examined, using a reaction temperature of 500 – 550°C . At this high temperature, bearing in mind the results with plain carbon steels, it is possible that the recorded results may be low, but in the absence of direct comparison it was not possible to reach a definite conclusion. With regard to the vacuum fusion method, previous investigations suggest that it may give good values for the total oxygen content of certain steels. The ability of such a procedure to throw light on the amount and state of combination of the individual oxides, however, is still regarded as being open to doubt. The difficulty of controlling the many important factors in electrolytic methods makes the use of such methods impracticable at present, but further investigations might surmount the obstacles.

The determination of non-metallic inclusions in cast iron presents considerable difficulties. The effect of

sulphides and phosphides, using the chlorine method, is uncertain; Fe_3P and some MnS most probably remain undissolved when using the iodine method.

Corrosion-Proof Aluminium

ALUMINIUM has been electroplated with various corrosion-proof metals, but the coatings, generally, have not adhered in a reliable manner. A process is now being developed in Germany to cover aluminium with a strong coating, which gives a protective surface by itself and also lends itself to subsequent plating with nickel, copper, or chromium. The objects are plated by immersion in an alkaline solution of zinc, and the zinc coating is then dissolved away by means of nitric acid or a mixture of nitric, hydrochloric and sulphuric acids. The surface remaining is rough and hard and cannot be removed by any of the above acids. When nickel, copper or chromium are plated on this undersurface the platings are said to adhere tenaciously and are extremely durable; nickel platings from acid electrolytes are especially durable.

Various patents for the electrolytic oxidation of aluminium are now pooled in an international combine, of which three German concerns, Siemens and Halske, Langbein-Pfanhauser, and Vereinigte Aluminium Werke are members. The German concerns have an agreement among themselves to use only one process, that known as the "Eloxal" process. By pooling their patent rights with foreign concerns, however, the Germans have obtained access to many important foreign patents, such as the Bengough patents for colouring aluminium. The joint assets of the combine number over 300 patents concerned with aluminium processes and uses. Since the conclusion of these agreements in 1934, the Eloxal business in Germany has expanded rapidly; it is stated that the combined weight of aluminium goods coated by this process amounted to over 2,000 metric tons in 1935.

A New Rust-Proof Steel

A NEW German rust-proof steel claims the distinction of possessing a "warm" colour comparable to silver, in addition to being very ductile and therefore suitable for a variety of pressed-metal articles. This alloyed steel ("Roneusil") incorporates 8 to 9 per cent. of chromium and 12 per cent. of manganese, but no nickel; it is manufactured by Röchlingstahl G.m.b.H., of Vöcklingen, Saar. The steel is rust-proof, it is resistant to acids that ordinarily occur in foods, it has a whiter colour than carbon steel and the ability to take a high polish, it will not tarnish, and it may be soldered or welded. It is being used principally in the manufacture of tableware, excluding knife blades, as it cannot be hardened by heat.

The rust-proofing of iron and steel based on treat-

ment with a phosphate solution has been introduced in Germany in its original Parker version, and as a modification—"Atrament Verfahren"—controlled by the I. G. Farbenindustrie. The Parker process is operated in Germany, under American licence, by the Metallgesellschaft A. G., of Frankfurt-on-Main. Treatment time for the process has been reduced by the use of accelerators, which cause the iron surface to combine rapidly with the phosphate. The principal accelerator in use in Germany is zinc nitrate. For certain purposes objects are sprayed instead of immersed in a phosphate bath.

Analysis of Alloy Steels

FOLLOWING a critical review of earlier literature relating to a combustion method for the determination of sulphur in steel, and as a result of an extensive series of experiments in which possible sources of error were successively eliminated, apparatus and procedure have now been developed by which the determination of sulphur (or sulphur and carbon simultaneously) may be made within 15 minutes, by the actual combustion of the steel in oxygen at high temperature ("Ind. Eng. Chem.," Anal. Edit., 1936, 8, 317). According to C. H. Hale and W. F. Muehlberg, the method is applicable to all types of steel and gives results which are slightly lower than those commonly accepted, but those values are consistent and reproducible and are considered to be sufficiently accurate for most practical purposes, especially in the case of high-alloy steels containing low sulphur. Experiments designed to secure the determination of selenium simultaneously with sulphur and carbon show promising results.

Titanium in Nickel Alloys

THE use of titanium as a degasifying, cleansing, and generally corrective agent in steel is already well known, but its effect as an alloying element has not been studied so extensively. A recent paper by J. A. Duma (American Society for Metals) reports experiments which have been made in an attempt to evaluate the effect of titanium on the properties and behaviour of such cast alloys as low and medium carbon steel, cast low-nickel-chromium steel, copper steel, 8/18 nickel-chromium steel, monel metal and 70/30 cupro-nickel.

The influence of the titanium addition was determined as affecting mechanical properties, micro-structure, welding, general resistance to corrosion, machining and susceptibility to age-hardening. For nickel chromium steel (carbon 0.27, nickel 1.48, chromium 0.84, titanium up to 1.84 per cent.) low additions of titanium increase the tensile strength, yield point and hardness, but an increase of titanium above 0.20 per cent. impairs the ductility and toughness. Tests with a 4 per cent. salt spray solution showed that the nickel-chromium steels containing high titanium were more resistant to attack than the straight nickel-chromium steels. It was also noted that the titanium-treated steels were capable of taking a specially high polish and that they are readily machinable. Titanium also inhibited the formation of the hard transitional constituents produced on welding nickel-chromium steel of this type, but this cannot be utilised to advantage as the strength of the titanium-treated steel is too low.

In the case of austenitic 8/18 nickel-chromium steel

(containing up to 3.50 per cent. of titanium), the titanium materially raises the tensile strength and yield point, but also causes a definite lowering of impact strength and ductility. The titanium-treated steels are equal to the straight nickel-chromium steels in resistance to salt-spray attack, but show a lower resistance to nitric acid. Titanium additions to nickel-copper alloys (monel metal and 70/30 cupro-nickel, containing 0.038 per cent. titanium), in the small percentages used, enhance the tensile strength without seriously impairing ductility, and this effect is considered to be due to the fact that the carbon in the titanium treated nickel-copper alloys is present in the combined and not in the graphitic form. Titanium improves the machining properties to an appreciable extent and resistance to corrosion by saline atmosphere is not seriously affected.

The Platinum Market

THE active market in Germany for platinum resulted in heavy importations for the first seven months of 1936. Of the total 15,310 kg. of platinum-group metals imported, Soviet Russia supplied 13,990 kg. In England the official price of platinum fell from the peak of £14 per ounce on September 2, to £10 15s. on October 12. This reduction represented an attempt to bring the official price into line with the level at which speculators were trying to liquidate their holdings.

Speculation in platinum metal was initiated in New York early in 1936, when platinum was offered as an alternative to gold for hoarding purposes. The corporation concerned bought the metal and deposited it in a bank in the form of 3-ounce ingots, numbered and stamped for weight and fineness. Certificates were then issued on the backing of the metal held in the bank, and outside speculators dealt in the certificates at prices as much as £2 above the value of the metal. Speculation soon assumed serious proportions and the price of the metal advanced steadily. When the peak price of £14 was reached early in September a number of speculators attempted to take profits, but consumers who were already well supplied refused to buy and the speculative holdings were then offered at declining prices.

A. H. Atkinson and A. R. Raper, both of the Mond Nickel Co., Ltd., gave special attention to the subject of platinum at the autumn meeting of the Institute of Metals, which was held in Paris. They stated that the principal alluvial deposits of crude platinum, in order of importance, were found in the Ural Mountains, Colombia, and Abyssinia. There are also very extensive primary deposits of platinum metals in the Rustenburg and other districts of the Transvaal. These deposits contain about 10 pennyweights of the platinum metals per ton, with the platinum and palladium about equal in proportion, and smaller amounts of the other platinum metals. Platinum and palladium are also found in combination with arsenic in the copper and nickel-bearing deposits of the Sudbury district of Ontario, Canada. Although this Sudbury ore contains a very small amount of platinum metals per ton, it is the large tonnage treated for nickel and copper extraction which makes it possible to recover a substantial amount of the rare metals as a by-product.

Recent Research on Iron and Steel

Papers Read at the Autumn Meeting of the Iron and Steel Institute

INVESTIGATIONS on the influence of vanadium on nickel-chromium and nickel-chromium-molybdenum steels were reported by H. H. Abram, M.Sc., F.Inst.P., of the Research Department, Woolwich, in a paper read at the autumn meeting of the Iron and Steel Institute (September, 1936). It was found that in the two types of steel examined, additions of vanadium exceeding 0.1 per cent. tended to preserve almost constant mechanical properties when the hardened steels were progressively tempered throughout the range 500°-650°C. This was due to the temper-hardening caused by the precipitation of vanadium carbide from supersaturated solution in alpha-iron, counteracting the normal softening produced by tempering from 500° to 650° C. This effect of vanadium on the mechanical properties permits considerable latitude in the tempering temperature. The hardened and tempered steels possessed a good combination of mechanical properties, and no important reduction in the notched-bar impact value (relative to hardness) was associated with the temper-hardening effect. For the steels examined the most suitable vanadium content appeared to be 0.15-0.25 per cent.

Constitution of Slags

A paper by T. P. Colclough on the constitution of blast-furnace slags in relation to the manufacture of pig iron dealt with the changes in constitution and properties of the slag arising from variations of the alumina content and the basicity ratio, and offered an explanation for the difficulties encountered in the smelting of certain British iron ores, and particularly those which carry a relatively high ratio of alumina to silica, when smelted in accordance with the rules of burdening accepted in common practice. The view was advanced that the blast-furnace operation should be based on the principle of attaining the maximum rate of production of iron per unit of capacity, with the minimum coke consumption, and the corresponding lower operating costs. The theoretical and practical considerations necessary to attain this objective were discussed, and a new principle of burdening was suggested. It was recommended that, no matter what quality of ore and/or coke is to be smelted, the burden should be arranged so that the slag formed approaches as nearly as possible to that of minimum melting point and minimum viscosity for the given alumina content, and that for this purpose the ratio of lime to silica in the burden shall be varied according to the alumina content of the slag formed. The limiting values of the basicity ratio to be preferred were indicated. It has been proved that the difficulties normally encountered with slags outside the normal range of 14 to 18 per cent. alumina can be carefully overcome, and examples were given of the results to be obtained in practice from the application of this new principle.

Tantalum Alloys

In a paper on tantalum-iron alloys and tantalum steels, R. Genders, D.Met., F.I.C., and R. Harrison, B.Sc., of the Research Department, Woolwich, described a study of the constitution of the tantalum-iron system, an examination of the effect of tantalum and niobium on the structure and properties of carbon steels and of 4 per cent. nickel steel, and the development of tantalum as an alloy-steel element in nitriding steels and tool steels. The tantalum-iron system contains two eutectics formed by the compound Fe_2Ta with δ -iron and with tantalum at compositions of approximately 20 per cent. and 80 per cent. of tantalum respectively. Below a tantalum content of 6.5 per cent. the δ solid solution is resolved, on cooling, into a eutectoid of γ -iron and Fe_2Ta . The solubility in γ -iron decreases with decrease in temperature to the γ -iron into α -iron inversion. The solubility of Fe_2Ta in α -iron is small.

Tantalum-niobium mild steels conform metallographically with the main features of the pure alloys. The effect of tantalum is to decompose iron carbide, and with excess of tantalum the carbon steels consist essentially of iron-tantalum alloy with tantalum carbide, a compound which is insoluble and inert to heat treatment. Tantalum-iron alloys nitride readily in dissociated ammonia at 500° C. and give deep penetration with increase in hardness. Extremely high hardness of the order obtainable in commercial nitriding steels is attained, together with deep penetration, by the addition of aluminium to tantalum steels. The reaction between tantalum and iron carbide provides a means of producing steels containing included carbide particles by the use of a high-carbon basis material, such as pig iron. By melting ferro-tantalum in contact with carbon, a product is obtained from which the carbide may be isolated by chemical means for use as an abrasive or sintered cutting material.

Non-Metallic Inclusions

The effect of non-metallic inclusions on the graphite size of grey cast iron was discussed by A. L. Norbury, D.Sc., and E. Morgan, M.Sc., of the British Cast Iron Research Association, Birmingham. Their investigation dealt with the problem that the graphite size and properties of grey cast irons made from different pig irons, or made under different melting conditions, can vary widely from some cause not explained by chemical analysis, &c. Experiments were made on small $\frac{1}{4}$ lb. crucible melts of grey cast iron to see if gases or non-metallic inclusions in the metal were the cause. These led up to the observation that dissolving 0.1 per cent. to 0.2 per cent. of titanium and bubbling carbon dioxide gas through the melt completely refined the graphite structure of all hypoeutectic grey cast irons. Bubbling hydrogen through melts treated in this way coarsened the graphite structure completely. The titanium content of various pig irons and ferro-alloys was also found to determine the fineness of the graphite structures produced from them when they were remelted under oxidising conditions. A theory put forward to explain these and other results suggested that treatment with titanium and carbon dioxide produces titanate inclusions which are liquid externally when the graphite crystallises and that, being liquid, they do not inoculate it, and supercooling occurs, which produces fine graphite. On the other hand, additions of silicon, calcium silicide, and aluminium are suggested to produce solid and consequently inoculating inclusions, such as silicates, calcium carbide, and alumina, in the melt, and coarse graphite results. The action of hydrogen is assumed to be due to iron oxide being reduced from the titanate inclusions and their freezing point being raised.

Other experiments on cupola-melted metal showed that it was more difficult to refine than crucible-melted metal, since the titanium, on dissolving, combined with inclusions already present in the metal, and floated up out of the melt. It was also found that titanium-containing charges which gave the graphite casts when melted in the crucible, gave coarse graphite casts when melted in the cupola. This coarsening is suggested to be due to reducing conditions operating, in certain parts of the cupola, on inclusions previously formed by oxidation, and having a similar effect to hydrogen.

Controlled Grain Size

The effect of controlled grain size on mechanical properties of steel and some suggestions concerning the theory involved, was the subject of a paper by T. Swinden, D.Met., and G. R. Bolsover, F.Inst.P. The authors considered that the subject of controlled grain size in steel has not received the recognition in this country which it deserves, and presented tests on a selection of steels made specially to demonstrate the difference in physical properties between relatively coarse and fine grain on the same cast of steel. Eighteen

types of steel were used, in which the only variable within practical limits is the grain size. Inherent grain size is a characteristic of the steel controllable as a function of steel-making. It was shown that fine grained steel, compared with coarse grained steel of precisely similar quality, has certain well-marked differences in physical characteristics, and that where the engineer desires a better Izod value with a given tensile strength, or conversely a somewhat higher tensile strength with a given Izod value, it is advisable to consider the possibility of achieving the objective by a study of controlled grain size as an alternative to the use of a more highly alloyed steel. While the main objective of the paper was to record facts based on an extended experience, some views were expressed on the fundamental theory underlying the process of manufacturing steel of controlled grain size. It was suggested that inherent grain size is a function of the ultimate degree of deoxidation during steel manufacture.

In a paper on the determination of non-metallic inclusions

in steel and iron, E. W. Colbeck, S. W. Craven and W. Murray stressed the importance of the need for obtaining information with regard to the constitution of the non-metallic matter included in iron and steel. They then reviewed various methods proposed for the isolation and analysis of such inclusions. A detailed description of the use of chlorine for this purpose, and its effects at different temperatures on SiO_2 , Al_2O_3 , Fe_2O_3 , and Mn_2O_4 was outlined. These oxides have been tested both singly and as mixtures in the presence of carbon. Comparative results obtained on a number of carbon steels by several solution methods were given, particular attention being directed to the use of chlorine and iodine. Typical residues from chlorine and iodine attack were examined by X-ray analysis, and it was shown that MnS is not completely soluble in iodine. The authors also dealt with the determination of non-metallic inclusions in cast iron, showing by chemical and X-ray analysis that Fe_3P is quantitatively retained in residues after iodine extraction.

Sintered Metal Powders

"Powder Metallurgy"

OF recent years, mainly due to active propaganda in the United States, the attention of the metallurgical world has been drawn to the useful products, with unique properties, obtained by moulding under compression various metallic powders and afterwards submitting the moulded forms to controlled heat-treatment with the object of securing cohesion of the particles, or, in the case of mixed metallic powders, cohesion accompanied by alloying.

In its essential features this branch of metallurgical technique is over a century old, and may be said to have had its origin in England where Wollaston prepared platinum in a form suitable for fabrication into useful articles by compressing platinum powder, raising the pressed material to a welding heat, and subjecting it to mechanical working, producing in this way sheet or wire.

Very little was heard of this branch of metallurgy until the early years of the present century, when Von Bolton, of Siemens and Halske, produced metallic tantalum in the ductile form by working on compressed and sintered forms of the powdered element, states an article in "Alloy Metals Review" (Vol. 1, No. 1), published by High Speed Steel Alloys, Ltd. A few years later, Coolidge, of the General Electric Co., United States, made malleable and ductile tungsten by similar methods, starting with pure hydrogen-reduced tungsten powder, incidentally achieving a scientific triumph by proving that this element, generally understood before his work to be brittle, was really one of the most malleable and ductile of metals.

Very definite advantages are found to result from powder metallurgy, and while the cost of making the powders would seem an objection to the process, the advantages are in many cases sufficient to more than offset this initial handicap. It is found that alloys not easily produced by ordinary procedure can be made to very definite specifications and moulded articles such as commutator segments, name-plates, door-knobs, etc., etc., can be made cheaply and without loss of metal. An established and commercial use of the process is the production of self-lubricating bearings formed by compressing powdered metals in moulds with subsequent heat-treatment.

By suitable adjustment of the metals employed, the grain sizes, the pressure and heat-treatment, the degree of porosity can be varied within wide limits.

By powder metallurgy non-metallic bodies can be incorporated into a metallic matrix, and useful properties can thus be obtained. For instance, graphite can be combined with copper powder to form dynamo brushes, fluxes can be blended

with the metal in soldering and welding rods, and carbides of the rarer metals, with binding metals, can be formed by pressure and sintering into hard cutting tools and dies. Again, metals which do not readily alloy can be formed into mechanical mixtures and compressed into solid form to yield products combining the useful functions of the constituent metals. Thus, copper containing small percentages of chromium, tungsten, combined with copper or silver, and similar mixtures can be formed to utilise the high conductivity of copper and silver and the hardness of the other metals.

The commercial use of powder metallurgy is still in its infancy despite its application to platinum for over a century. The chief limitation of its rapid expansion is perhaps the necessity for heavy compression which makes the use of very large presses necessary for other than quite small products.

Microscopic Examination of Tin

Preparing Specimens of Soft Metals

IMPROVED methods of mounting and polishing soft metals, such as tin and its alloys, for examination under the microscope are described in a new research report of the International Tin Research and Development Council. This report, "The Preparation of Tin and Tin Alloys for Microscopic Examination," by H. J. Taffs, F.R.M.S. (Technical Publications, Series A, No. 47) is reprinted from the "Journal of the Royal Microscopical Society," 1936, 56, 300.

Although the technique of preparing hard metals is well established, there are usually difficulties if it is applied to soft metals like tin. The paper discusses the advantages and disadvantages of mountants in general use and explains the suitability of bakelite, giving practical directions. Liquid synthetic resin mixed with a hardener is poured into a mould so as to surround the specimen. Standing for a day at room temperature, or an hour or two at $40^\circ\text{--}60^\circ\text{C.}$, causes the resin to solidify into a hard adherent moulding. This method is preferable to that in which similar resins are subjected to great pressures and much higher temperatures since it does not affect the structure of the metal to be examined.

Special refinements in polishing and etching are described and photomicrographs of specimens prepared by ordinary methods, and of the identical fields prepared by the new technique, show the considerable gain in definition which the methods make possible.

An International Electrodeposition Conference

To be held in London, March 1937

THE Electrodepositors' Technical Society has decided to sponsor an international conference on electrodeposition, to be held in London, March 3 and 4, 1937. A number of American and Continental experts have been approached and have unanimously expressed their opinion of the need of such an opportunity of bringing together those who are interested in the science of electrodeposition.

The practical applications of electrodeposition are so varied that there is scarcely an industry that would not benefit either directly or indirectly by advancement in the knowledge and technique of this subject. Wherever metals are used electroplating plays a part which may be either decorative or corrosion resistant, and the decorative uses alone, which are too numerous to name, range through thousands of manufactured products in constant daily use. Printing and gramophone record production are dependent upon the practice of electroforming; in the engineering trades the facing of tools and gauges and the replacement of eroded metals is brought about by electrodeposition; while a considerable portion of the world's supply of non-ferrous metals is made available through the agency of electrolysis.

Progress in the industrial development of electrodeposition has recently been very rapid. There have been improvements in the method and plant used, and the scope of the industry has been widened by the introduction of new processes. This development has not been confined to any one country. Experience in other industries has shown that a conference such as the society proposes to organise leads to further stimulation of progress and to personal contacts of great educative value.

The Electrodepositors' Technical Society has always taken the lead in such developments in this country, and by means of meetings, circulation of papers, and the arrangement of exhibits has used every endeavour to add to the knowledge both of those employed in the industry and of the public who eventually purchase and use electroplated and deposited products.

The council of the society feel that it is in keeping with the historical development of the industry that the first International Electrodeposition Conference should be held in London. Since the society's own funds, however, do not allow it to undertake the organisation without some measure of outside financial support it has been decided to appeal both to the industrial interests that stand to benefit by the progress of electrodeposition, and to those to whom the educational interest is of paramount importance. Subscriptions should be forwarded to the hon. treasurer, Mr. F. L. James, "Fowey," Oakleigh Road (North), Whetstone, N.20.

According to the provisional programme, Wednesday, March 3, will be devoted to the opening ceremony at British Industries House, followed by a luncheon. The subject of the afternoon session will be "Electrodeposition Practice Abroad"; that of the evening session, "Electrodeposition of Base Metals." On Thursday, March 4, the morning session will be devoted to "The Properties of Electrodeposits"; at the afternoon session to "Electrodeposition of Precious Metals." On Thursday evening there will be a reception and dinner. Papers have been accepted from Belgium, Czechoslovakia, France, Germany, Holland, Russia, Switzerland and the United States.

Some Recent Metallurgical Patents

Iron Silicon Alloys

In a process of making iron-silicon alloys containing 15-16 per cent. of silicon, pig iron is dephosphorised by means of lime, and desulphurised and deoxidised by means of ferro-manganese with the addition of lime and barium oxide. The carbon content is then adjusted to 3 per cent. by the addition of potassium ferrocyanide, and degasification is effected by means of ferro-titanium and magnesium. Ferro-silicon, preferably containing about 94.8 per cent. of silicon, is then added, in admixture with petroleum coke, in such quantity as to secure the desired silicon content in the product, followed by an addition of potassium cyanide and petroleum coke, a final degasification being effected by means of magnesium and calcium. In some cases 0.1-0.2 per cent. of boron, in the form of ferro-boron, may be incorporated in the alloy. (See Specification 451,463 of Malschaert, R.).

Deoxidising Ferrous Metals

To extract oxides from ferrous metals, *e.g.*, steel, acid slags are used in which the ratio of the manganese oxide content to the iron oxide content is equal to or greater than 4, the content of manganese oxide being preferably greater than 5 per cent. Periodic regeneration of the slag is effected to restore or maintain the value of the manganese oxide-iron oxide ratio. The slag may be melted and intermixed violently with the metal or may be used in the solid state in a ladle. The manganese oxide content may be so high, *e.g.*, up to 30 per cent., that manganese is introduced into the metal, and the metal may also be enriched in silicon by reduction of silica in the slag. The iron oxide content of the slag is low, *e.g.*, less than 4 per cent. The regeneration of the slag

is effected by reduction of iron oxide by means of a reducing agent followed by replacement of part of the slag by fresh materials to compensate for any increase in the manganese oxide content and to restore the initial composition as regards silica and any basic materials, *e.g.*, calcium oxide. If the metal has been enriched in manganese, manganese oxide must be added to the slag during regeneration. (See Specification 451,263 of Soc. D'Electro-Chimie, D'Electro-Metallurgie et des Acieries Electriques D'Ugine).

Protecting Steel Against Oxidation

A protective case is formed on cast iron or steel by subjecting the metal to sand-blasting, coating with a thin layer of aluminium, *e.g.*, by spraying, covering the aluminium layer with a very thin layer of a metal such as copper, mild steel, or rustless steel, and then subjecting the metal to heat to cause the aluminium to alloy with the base. The thin layer of copper, mild steel, etc., prevents oxidation of the aluminium during the heating and subsequent cooling. The heating may be effected in a furnace or when the article is in use. If desired, the thin layer of copper, mild steel, etc., may be subsequently removed, *e.g.*, by sand-blasting. The treatment of mechanical parts, furnaces, boiler, and stove fittings, vats and troughs, and annealing boxes is referred to. (See Specification 451,472 of Soc. Anon. Des Hautsfourneaux de la Chiers).

Distilling Magnesium

THE magnesium vapours from the reduction of magnesium oxide by the process of the parent specification are suddenly chilled to a temperature at which magnesium and carbon monoxide are stable in the presence of each other, by inti-

mate commixture with finely divided and preferably cooled hydrocarbon oils, an inert or reducing gas preferably being employed as dispersion medium. Ordinary atomisers with or without an impingement plate may be employed. The ribs are separated from the magnesium dust as by means of a filter press and the solid residue freed of remaining oil by heating after which it may be converted into compact metal by known methods. This step may be facilitated by driving off the residual oil at a temperature effecting a partial cracking so that a crumbly mass of magnesium dust and coke is obtained. (See Specification No. 448,536, of Österreichisch Amerikanische Magnesit Akt.-Ges.)

Bronzing Copper

COPPER and copper alloys, especially brass, are bronzed by first rubbing the polished surface, freed from grease if necessary, with a swab which has been moistened with a solution of water, hydrochloric acid and copper sulphate, then removing any residues adhering to the slightly corroded surfaces and then treating with a stream of gas containing ammonium sulphide so that the gas sweeps over the metal surface. The acid solution is made up of 1,000 c.c. of water, and 20 c.c. of concentrated hydrochloric acid in which is dissolved 20 grams of crystallised copper sulphate. To produce the stream of gas, air or other gas which does not decompose ammonium sulphide is led from a compressed air, etc., container or a hand-blower through a 10 to 20 per cent. solution of ammonium sulphide. To eliminate any cloud or spot formation in the bronzed surface, the latter is rubbed down lightly with a polishing powder or again treated with the acid solution. (See Specification No. 447,446, of Metallwerke Akt.-Ges., Dornach.)

Refining Rhodium

Alloys particularly suitable for making pen nibs, chemical apparatus, reflectors, electrodes, and for dental and other purposes consist of nickel and 25-80 per cent. of rhodium. Part of the rhodium may be replaced by up to 20 per cent. of platinum or iridium, subject to there being at least 10 atomic per cent. of rhodium and at least 20 atomic per cent. of rhodium, platinum, and iridium present, and part of the nickel may be replaced by up to 55 per cent. of palladium, up to 10 per cent. of molybdenum or tungsten, or up to 20 per cent. of copper, iron, or cobalt. In making the alloys, a scavenging element such as magnesium, zinc, manganese, silicon, boron, barium, calcium, titanium, or zirconium may be added in such amount as to leave up to 0.2 per cent. of such amount as to leave up to 0.2 per cent. of such element in the finished product. The rhodium used may be purified by melting it in a carbon-free crucible and subjecting it to alternate reduction and oxidation. (See Specification 451,823 of Mond Nickel Co., Ltd.).

Treating Tin Alloys

IN a process for treating tin bearing metal such as tin-lead or tin-antimonial lead, a molten bath of such metal is treated with an oxidising agent in the presence of lead chloride, the tin being oxidised and concentrated in the slag. The oxidising agent used may be air which is introduced through a pipe into the bath or a solid substance such as litharge, nitre or lead oxide-lead sulphate. The lead chloride may be used alone or mixed with other salts such as sodium chloride. The lead chloride is recovered from the slag either by fuming or by leaching the slag with a hot concentrated brine solution and recovering it from the leach solution. The residue containing the tin may be reduced with coke to produce metal of high tin content. In an example, an alloy containing 72.2 per cent. of lead, 4 per cent. of tin, 22.1 per cent. of antimony, 0.28 per cent. of arsenic and 0.89 per cent. of copper was treated with an eutectic mixture of lead and sodium chlorides and then litharge added, the bath being stirred for

an hour at 950° to 1,000° F. The tin slag was skimmed off and the process repeated. The final metal contained 70.1 per cent. of lead, 0.1 per cent. of tin, 21.0 per cent. of antimony, 0.73 per cent. of arsenic, and 0.62 per cent. of copper. (See Specification No. 447,713, of E. L. W. Byrle.)

Refining Niobium Alloys

Niobium alloys containing silicon in excess of a ratio of one part of silicon to six and a half parts of niobium are wholly or partially freed from tin by treating them, preferably in a comminuted condition, with a solvent for tin, which may be sulphur chloride or hot caustic alkali, but is preferably an acid such as hydrochloric acid. The minimum silicon-niobium ratio corresponds to that present in niobium-silicide Nb₂Si, and tin may be removed from alloys originally containing less silicon by increasing their content of silicon prior to treatment with acid. The alloys for treatment may be obtained by smelting with stanniferous niobium oxide ores a reducing agent such as carbon, aluminium, or silicon, and the required silicon content may be obtained by reduction of silicon with the ore or by alloying a niobium alloy with silicon. In examples, the alloys treated contain, in addition to niobium, tin, and silicon, mainly iron and tantalum. (See Specification 450,857 of Electro Metallurgical Co.).

Beryllium Supplies

International Position

BERYLLIUM metal has become of considerable industrial importance, principally as an alloying agent with copper, with which it produces some remarkable and valuable metal products. In "Deutsche Bergwerks Zeit.," July 16, 1930, some information was supplied as to the international status of beryllium production, in connection with the State decree prohibiting the export of beryllium metal or alloys from Germany.

Apart from the United States, Germany is the only country producing beryllium metal. There it is produced by two undertakings, *i.e.*, the Deutsche Beryllium Studiengesellschaft (of Siemens and Halske), and the Heraeus Vakuum-Schmelze, at Hanau. In 1934 these two concerns came to an agreement under which Heraeus undertook the production and sale of beryllium and its alloys, and an agreement was made for co-operation between the German concerns and the Beryllium Products Co. (Beryllium Corporation, of New York) to exchange patents and technical and scientific experience. The Deutsche Gold-und-Siberscheideanstalt, in Germany, produces beryllium oxide for use in the ceramic industry. In the United States, two concerns are also producing beryllium metal, *i.e.*, the Beryllium Corporation, of New York, and the Brush Beryllium Co., of Cleveland Ohio.

Beryllium metal is obtained principally from the mineral beryl, which contains about 4 per cent. of beryllium; other beryllium-containing minerals have less than 1 per cent. of the metal.

The consumption of beryllium, especially in the form of copper-beryllium alloys, and as oxide in the ceramic industry, is increasing; this suggests that the present high price of the metal is not likely to be reduced. The price of beryllium in Germany for several years past has remained at 600 marks per kg. In 1934, the quantity of beryl treated for beryllium production averaged about 35 tons per month, but since then it has almost certainly become greater.

THE Electrolytic Zinc Co. of Australasia, Ltd., which at one time was under German control, plans to extend the variety of produce of its plant in Rosdon, Tasmania, to include other electrolytically produced metals in addition to zinc. It is due largely to this concern that Australia now consumes 40 per cent. of its own zinc.

Metallurgical Section

February 6, 1937

Some Recent Modifications of Alloy Steels

A SURVEY of various types of steel used by important industries, *e.g.*, automotive, aviation, railways, ship-building and mining, indicates that chromium steels are being more widely used than ever before. The general tendency is to use more of this type of steel for heat-resisting and corrosion-resisting applications and also to give added strength in structural applications. New limits to the chromium content, and suitable additions of other elements, are making many of these chromium steels more economical in use and more widely applicable. A new 9 per cent. chromium steel containing molybdenum is claimed to be suitable for severe service at petroleum refineries and power plants. For high-pressure service, where resistance to shock and the decarburising effect of hydrogen at high temperature is desired, good results are obtained with 1.5 to 2.75 per cent. of chromium and the addition of molybdenum and vanadium. Another recent modification is a 2 per cent. chromium steel containing columbium. The widely used 4 to 6 per cent. chromium steels themselves have also been improved by the addition of either columbium or titanium. Such chromium steels containing tungsten or molybdenum, as used for condensers and tubing in oil cracking plant, are found to be improved when columbium is added.

The primary function of columbium is to control the carbide constituents of chromium steels. Possible applications have existed where plain chromium steel would have proved exceedingly useful had its air-hardening characteristics been modified or eliminated, and research has now proved that columbium is very effective in overcoming or modifying the air-hardening properties. Columbium is used in 18-8 chromium-nickel stainless steel welding rods, with either columbium or titanium in the stainless base metal, to inhibit any tendency toward intergranular corrosion that might otherwise be present in or near the welds. The amount of columbium added is determined by the carbon content of the steel and by the temperature at which the steel is to be used. With the correct amount of columbium it is not necessary to anneal structures which have been fabricated by welding in order to obtain freedom from intergranular corrosion.

In another direction the addition of nitrogen has been found to improve the grain structure. Steel castings containing over 20 per cent. of chromium have been in use for many years in applications where resistance to corrosion, high temperatures, and excessive wear has been desirable. Such castings have shown a tendency towards the formation of a large grain structure and also towards grain growth when held at a high temperature for long periods. The addition of nitrogen to such alloys, however, has been found to have the effect of reducing the tendency to grain growth at high temperature, and also of refining the grain structure. The combined result is a marked increase in

the ultimate strength, yield point, elongation, etc., of the steel. The nitrogen is added in the proportion of about 1 part of nitrogen to 120 parts of chromium, and is introduced in the form of high-nitrogen ferrochrome. Nitrogen is also added to chromium steel ingots to induce the formation of a fine grain, which then makes the alloy more adaptable to deep drawing operations.

Coarse and Fine Grain in Steels

CONTROLLED grain size in steel was discussed by Dr. T. Swindon and Mr. G. F. Bolsover in a paper which they read at a meeting of the Staffordshire Iron and Steel Institute, held jointly with the Iron and Steel Institute, at Birmingham, on January 19. It was suggested that the subject of controlled grain size in steel had not received the recognition that it deserved, so far as Great Britain was concerned. Results of tests on a selection of steels made to demonstrate the difference in physical properties between relatively coarse and fine grain on the same cast of steel were given. Eighteen types of steel had been used in which the only variable within practical limits was the grain size. Fine-grained steel, compared with coarse-grained steel of precisely similar quality, had four well-marked differences in physical characteristics. In the first place, there was greatly enhanced toughness as judged by the Izod (notched-bar) test with particular reference to plain medium-carbon and low-alloy steels; this resulted in a more dependable and uniform product. Secondly, there was a less but still beneficial effect on higher-alloy steels, with particular reference to certain types of brittleness. Thirdly, in mild steel, quench-ageing was not accompanied by any reduction in toughness, and the reduction in toughness by strain-ageing was very considerably reduced. Fourthly, the use of steel of controlled grain size facilitated heat treatment. Dr. Swindon and Mr. Bolsover agreed with the view of American observers that the use of aluminium in producing fine-grained steel did not increase the number of deleterious non-metallic inclusions.

A Distinguished Metallurgical Career

PROFESSOR WILLIAM CAMPBELL, professor of metallurgy at Columbia University, who died recently at the age of sixty, was born at Gateshead-on-Tyne in 1876, graduated from King's College, London, in 1892, and subsequently studied at Oxford. He became a research scholar at the Royal School of Mines, London, in 1899, and joined Columbia University in 1902, where he became How Professor of Metallurgy in the School of Mines in 1924. During his distinguished career in the United States, Professor Campbell held the office of metallographer for the technological branch of the United States Geological Survey. At one time he was also a member of the

advisory committee of the Bureau of Standards, advisory metallurgist to the New York City Board of Transportation, and metallurgist to the New York Navy Yard under war time conditions. Professor Campbell was a Fellow of the Geological Society and a member of the Institute of Metals. The Society of Chemical Industry awarded him the Saville Medal in 1903.

Atomic Weight of Aluminium

THE atomic weight of aluminium has recently been re-determined at the National Bureau of Standards in the United States. In this determination weighed portions of the metal were converted to the hydroxide and sulphate, respectively. These products were then heated until they changed to the oxide, Al_2O_3 , which was finally ignited at 1,200 to 1,300° C. By this procedure the atomic weight is related directly to that of oxygen. Careful analyses showed that the metal contained only very small quantities of impurities and disclosed no gases in the highly ignited oxide. Proper corrections were made for the small amount of impurities in the metal, and special precautions were taken to prevent the absorption of moisture by the ignited oxide during weighing. As obtained under these precautions the value for the atomic weight of aluminium was found to be 26.974, plus or minus 0.002. A complete account of the investigation as carried out by Mr J. I. Hoffman and Mr. C. E. F. Lundell, is published in the "Journal of Research" for January, 1937.

Non-Ferrous Metal Control in Germany

THE Board of Control for Non-ferrous Metals in Germany has recently issued a new set of regulations governing the use of non-ferrous metals for constructional purposes. The salient feature of these regulations, as contrasted with those previously in force, is the prohibition of the manufacture of such intermediate products and shapes for further manufacture into prohibited articles and machine parts. The metals affected are copper, nickel, tin, lead, sheet zinc, and mercury. Besides the prohibition of the use of non-ferrous metals in building or machine construction, there are departures in the uses of materials heretofore considered orthodox. Nevertheless, the Board of Control states that nothing has been placed on the list without making sure that a serviceable substitute material is available. Sheet zinc, for instance, may not be used as a roofing material or for gutters. Mercury compounds may not be used for protective treatment of wood. Condensers can be made of brass, but without nickel admixture. Lead may not be used in waterproofing pipe joints, in weights, counterweights, or stands. Various uses of copper, nickel and brass have also been prohibited in textile machinery, combustion engines, compressors, refrigerators, pumps, and equipment used in the food and beverage industries. To give another example, non-ferrous metals are forbidden to be used for insecticide spraying apparatus.

Structure of Thin Metallic Films

THE structure of thin metallic films continues to be investigated by Dr. S. Rama Swamy, of the Indian Institute of Science, Bangalore. In an earlier paper ("Proceedings of the Indian Academy of Science," A, 1934, 1, 347) the scattering of light by thin films of metal obtained by evaporation in vacuo was studied,

and it was found that a metallic film prepared by the method described in that paper could be divided into three parts, viz., a central metallic part which was highly conducting and scattered very little light, a part which scattered light intensely, and had a high electrical resistance, and a part which also scattered light, though a little more feebly, but was non-conducting. From these results, it was suggested that the metallic film has three possible different states, i.e., a crystalline state where there is complete regularity of arrangement of atoms, and consequently very little scattering of light, a two dimensional gaseous state with random distribution, and an intermediate state between these two. New work now reported by Dr. S. Rama Swamy ("Proceedings of the Indian Academy of Science," A, 1936, 4, 656) was taken up with a view to obtaining direct evidence of the amorphous state of metals in thin films by their study with the help of the electron diffraction method which has been developed by G. P. Thomson ("Proceedings of the Royal Society," A, 1930, 128, 641), G. I. Finch ("Transactions of the Faraday Society," 1935, 31, 1051), and others. Films of silver and gold were obtained by the evaporation of the metals in vacuo in a slightly modified form of the apparatus previously employed, and the metals were condensed upon surfaces of freshly split pieces of mica. Previously to introducing them in the electron diffraction camera, specimens cut from the mica were washed in petroleum ether about half a dozen times in order to remove all traces of grease and were then immediately inserted in the camera. Direct evidence was then obtained for the existence of thin films of gold and silver in the amorphous state as suggested in the earlier paper here mentioned. Films which were thin enough to scatter light gave electron diffraction patterns corresponding to an amorphous structure, but thicker films having metallic reflection and high electrical conductivity gave patterns corresponding to a polycrystalline structure.

Tin as a Hydrogenation Catalyst

IT is more than a year since a paper was read before the Institute of Fuel (November 22, 1935), announcing the advantages which result from the use of metallic tin as a catalyst for accelerating the hydrogenation of coal and oil. This discovery of the catalytic virtue of tin was originally made by Imperial Chemical Industries, Ltd., and its associated companies, and was almost immediately regarded as a matter of prime importance which would put the hydrogenation of bituminous coal on a practical basis. Most catalysts which had hitherto been used in the hydrogenation process were affected adversely by certain "poisons," such as sulphur, occurring in the materials treated. The removal of these "poisons" was, for economic reasons, not practicable. In 1929, however, it was found that tin is essentially immune from "poisoning," and arrangements were suggested for using the material in the form of tinned iron plates, arranged as a grid. Although these arrangements were successful, they were soon discarded in favour of a continuous injection of small quantities of certain organic compounds of tin. It was subsequently discovered that the range of coals which could be successfully hydrogenated was considerably increased by the use of coal cleaning, combined with the use of hydrogen chloride in the reaction vessels.

Some Aspects of Steel Chemistry

A Contribution from the United States

THE general subject of the chemistry of steel is so large that a whole course of lectures, and more than a single lecturer, would be required to discuss it thoroughly, states Dr. John Johnston, of the United States Steel Corporation, Kearny, N.J., in an article published in "Industrial and Engineering Chemistry," December, 1936. Such a discussion would bring up a number of points which have been settled only within recent years as a direct outcome of the more systematic scientific research directed to the solution of steel problems; it would raise a much larger number of questions, which cannot be answered except by further investigations along many different lines; and it would differ in many respects from what is in the textbooks read by chemists.

Factors That Have Been Neglected

The steel man uses the word "chemistry" in a special and limited sense—namely, to denote the composition of a steel, as determined by the usual analytical methods, with respect to carbon, manganese, silicon, and any other alloying elements which may have been added by intention. He has paid, in a sense, too much attention to this so-called chemistry, almost as if he believed that this alone determines the properties of the steel. Perhaps we should say rather that he has, until recently, paid too little attention to other factors which influence the useful properties of the steel—for instance, to small percentages of the non-metallic elements, oxygen, nitrogen and hydrogen, which are difficult to determine by analysis, yet do affect the steel in some ways, or to the precise conditions of rolling, finishing and cooling, which may exert an appreciable influence on properties now of practical significance. In short, recent work has demonstrated again and again that we must take into account not only this limited "chemistry," but everything which affects the real intimate structure of the metal; for its usefulness depends upon its real structure—its molecular architecture.

A change in structure brings with it some change in properties; a change in properties implies some change in real structure, even if we are unable to detect this change directly. Moreover, just as the mechanical stability of a building may depend largely upon the kind of cement used to tie the building units together, even though the total weight of the cement is only a small percentage of that of the whole building, so may the properties of a metal depend upon the kind, amount, and distribution of the material at its grain boundaries, as well as upon the kind, size, and shape of the grains themselves. A metal or alloy, as we use it, is an aggregate of crystal grains, which may be of one kind or of more than one kind, which may be large or small or may differ widely in size; and in manipulating metal, such as steel, in order to obtain the combination of qualities desired for a particular purpose, we are in effect altering the kind, size, and arrangement of our structural units, the crystal grains.

Steel-Making Processes

Reviewing in outline the general methods now commonly in use for making steel, the first step is the reduction, in the blast furnace, of the ore by coke with lime as a flux, to produce pig iron, which contains 3 to 4 per cent. carbon, usually about 1 per cent. silicon, and such other reducible metals as were present in the ore. As now carried out, this step is much more efficient than is commonly believed; further improvement is possible, but this is more in the direction of greater uniformity of product day after day than in improved efficiency in utilisation of coke or ore.

The next step is to convert the pig iron to steel and to refine the steel, either in (a) the Bessemer converter, (b) the open-hearth furnace, or (c) the electric furnace. In spite of the

apparent differences between these three processes, they are all essentially the same; each is a process of controlled oxidation, in which we try to oxidise out of the liquid metal those elements which we wish to eliminate from the steel and to retain in the right proportion those whose presence is considered desirable. Which of the three methods is used is largely a matter of relative economy and convenience, and of the precise kind of product specified. The greatest tonnage is now being made in the open-hearth furnace, a much smaller tonnage in the Bessemer converter; the more expensive electric furnace is limited to the making of special steels, particularly of so-called alloy steels, and the process is in many cases more a melting of the constituents than a refining of the product.

Control of Composition

It would lead too far to discuss the methods by which the composition of the liquid steel is controlled and adjusted. It must suffice to state that they involve direct control of (a) the temperature of the liquid steel, which in many cases must be brought up to within about 30° C. of the temperature at which the silica brick in the furnace roof melt down rapidly, (b) the composition of the slag, the slag being the reagent acting upon the liquid metal to alter its real composition, (c) the final rate of change of carbon and manganese content. Adequate control of these factors raises in turn many other problems such as the provision of methods of analysis which are accurate yet rapid enough to be useful in practice, or of refractory substances with the necessary combination of qualities, or even of a proper method of measuring the temperature, and so on.

Much of this control has been a matter of the personal skill of the operator, and it is wonderful what he can achieve on batches of 100 tons or more; but he is finding difficulty in meeting day after day the more and more rigorous specifications now imposed upon him (for instance, for a carbon range of 0.05 per cent. or even smaller, and indirectly for an oxygen range still smaller) and is perforce adopting methods of closer control developed by systematic investigation of the various problems.

The subsequent series of operations can be recounted briefly. The liquid steel is transferred from the furnace to a ladle, in which its composition may be finally adjusted by the addition of alloying elements and of deoxidising agents; from the ladle it is teemed or poured into ingot moulds in which it crystallises (the highest melting solid phases separating earliest) and finally solidifies. The solid, but still hot, ingot is removed from the mould, transferred to a soaking pit to bring it throughout to the proper temperature, and then rolled down to the shape desired. In all of these operations careful attention must be paid to the temperature, to a nice adjustment of the rolls, to proper heating, annealing, and cooling cycles, and to many other details.

Nature of Steel

Steel is an alloy of the elements iron and carbon, the latter in proportion ranging from a few hundredths up to about one per cent.; it usually contains manganese, to the extent of several tenths per cent., silicon in somewhat smaller proportions, as well as still smaller quantities of other elements (copper, sulphur, phosphorus), but none of these need concern us for the moment. When certain elements, such as chromium, nickel, or molybdenum, are added intentionally, the resultant steel is commonly called an alloy steel; but there is no sharp line of demarcation, and usage is not always consistent. In any case the significant point is that all steels are primarily alloys of the element iron, of which they usually contain 95 per cent. or more, often as much as 98 per cent. or

even more; and they owe their range of properties to the peculiarities of the element iron and of the iron-carbon system, peculiarities which are only modified by the presence of other alloying elements.

A steel is capable of being made hard or soft, brittle or ductile—in short, with a wide range of desirable properties—merely by choice of mode of heat treatment. This results directly from a property of the element iron, unique among the common metals, in that it occurs in two distinct crystal forms or atomic arrays, and from the circumstances that carbon is soluble in one of these forms but not in the other and that under many conditions of cooling and transformation proceeds slowly, or even very slowly. These two arrays are: (1) Ferrite or alpha-iron, body-centred cubic array, magnetic up to about 760° C., stable up to about 910° C., does not dissolve carbon beyond about 0.04 per cent. (2) Austenite or gamma-iron, face-centred cubic array, non-magnetic, stable above 910° C., dissolves carbon readily up to 1.7 per cent.

Effects of Heating

When a piece of substantially pure iron is heated, it expands regularly, but at about 910° C. it suddenly contracts, by about 1 per cent. of its volume, after which it again expands in a regular way though at a somewhat higher rate. Conversely, if the piece is cooled slowly from this temperature region, the gamma-iron first contracts, then expands suddenly as it goes to alpha-iron, which then contracts again regularly. The sudden change of volume is the signal of the transformation of one form to the other. As the gamma-iron is heated further, it continues to expand characteristically but at 1,410° C. changes again suddenly in volume, reverting to the alpha form; this then expands at its characteristic rate until it melts at 1,535° C. The element iron thus shows an interesting and nearly unique phenomenon in that it changes from alpha to gamma at 910° C. and back again at 1,410° C.

An element added to iron lowers this transformation temperature if it is less soluble in the low-temperature (alpha) form, in accordance with the general thermodynamic rule: carbon, nickel, and manganese act in this way. Conversely this transformation temperature is raised by addition of an element less soluble in the high-temperature (gamma) form, as is the case for chromium, silicon, and others. In the latter case the field within which gamma-iron (austenite) is stable becomes more limited with increase in the added element and finally vanishes. Any iron-chromium alloy which contains more than about 14 per cent. chromium shows no transformation and is always ferritic, a fact which lessens the range of usefulness of such alloys.

The control of properties by heat treatment would hardly have been possible if the transformation from gamma to alpha on cooling went as rapidly as the reverse transformation does when the steel is heated. We can obtain the wide modification of properties only because, as the steel is cooled, the transformation gamma to alpha sets in, not instantaneously as the real equilibrium temperature is passed, but only after a definite interval; and it requires another definite interval to go to completion. For a given steel these definite intervals depend upon the temperature at which the transformation actually goes, as is illustrated by the shaded band in the accompanying chart.

Transformation Temperature and Final Structure

This chart shows the typical relation, for a single steel, between actual transformation temperature and the time required at that temperature for the onset and completion of the reaction, austenite \rightarrow ferrite + carbide. The upper portion of this curve is entirely analogous to the similar curve showing the time required for a glass to devitrify (that is, to crystallise) at various constant temperatures. Its form is due to the fact that two main factors are involved in the reaction: (1) the departure from equilibrium or the "driving force," which increases steadily as the temperature is lower; (2) a factor analogous to viscosity—a resistance to diffusion

and precipitation of the carbon—which, as the temperature is lowered, likewise increases but at a rate greater than the driving force. Thus the viscosity factor, so to speak, overtakes the driving force and begins to delay, and finally in effect to stop, the reaction.

The form of the lower part of the curve is due to the fact that, if we cool the metal so fast that it does not stay long enough in the region of fastest transformation to permit the transformation to start (the process known as quenching), we obtain a different reaction and consequently a different product. With fast cooling the carbon, instead of precipitating, remains in supersaturated solution just as happens in many well-known cases; this is the typical constituent of hardened steel as produced by quenching and is known as martensite. This martensite, like ordinary glass, will, though unstable, persist for centuries at ordinary temperature; but when heated it changes, with partial or complete separation of its constituents. This is the process known as tempering, and the precise structure of the product depends again on the tempering temperature and on the time interval at that temperature.

Precipitation of the Carbon

This chart also illustrates how the actual transformation temperature affects the mode of precipitation of the carbon, and hence the structure and useful properties of the product. At a constant temperature just under the equilibrium temperature, the carbon precipitates in layers of lamellae spaced fairly regularly, yielding the type of structure known as coarse pearlite; at successively lower constant temperatures, the distance between lamellae becomes smaller and smaller until the pearlite is so fine that it is finally not resolvable by the microscope. There is thus a regular series of pearlites, from coarse to extremely fine, with a corresponding regular gradation in properties of the steel, which becomes continuously harder and stronger as the temperature of its transformation is lower. In other words, the architecture and hence the properties of a steel depend upon the temperature range within which the crystal transformation and consequent carbon precipitation actually occurred.

This temperature may be fixed by quenching the steel, while still austenitic, into a bath of molten lead or salt maintained at the desired temperature, and holding it there until the transformation is complete, as was done in preparing specimens for the photomicrographs incorporated in the chart. When this is done within the range 250° to 500° C., the product has remarkable properties; a piece brought by this method to a given hardness has much greater ductility and resistance to fatigue than a companion piece brought to the same hardness by the ordinary quench and temper method, corresponding to a marked difference in structure between the two pieces. The temperature at which transformation begins may also be altered by changing the rate of cooling to its onset. When this rate of cooling is slow, the actual transformation temperature is higher and the product softer; when it is rapid, the temperature is lower and the steel harder.

Really Pure Steel Not Desirable

We may have two steels of identical "chemistry," which yet differ in some of their significant properties, notably in response to heat treatment and in ageing characteristics. These differences depend upon the grain size, which in turn seems to depend upon the presence of very small proportions of certain non-metallic elements (notably, oxygen), and upon whether these elements are present in solid solution in the matrix or as solid particles at grain boundaries or within the grains. Incidentally, a really pure steel would not be desirable, because it would be too coarse-grained and remain so in spite of heat treatments; what is desired is the right kind of particle, properly dispersed, and this usually implies that in the finished liquid steel there must be some small proportion (measured in hundredths per cent.) of oxygen, and that this effective oxygen content must be kept within quite narrow

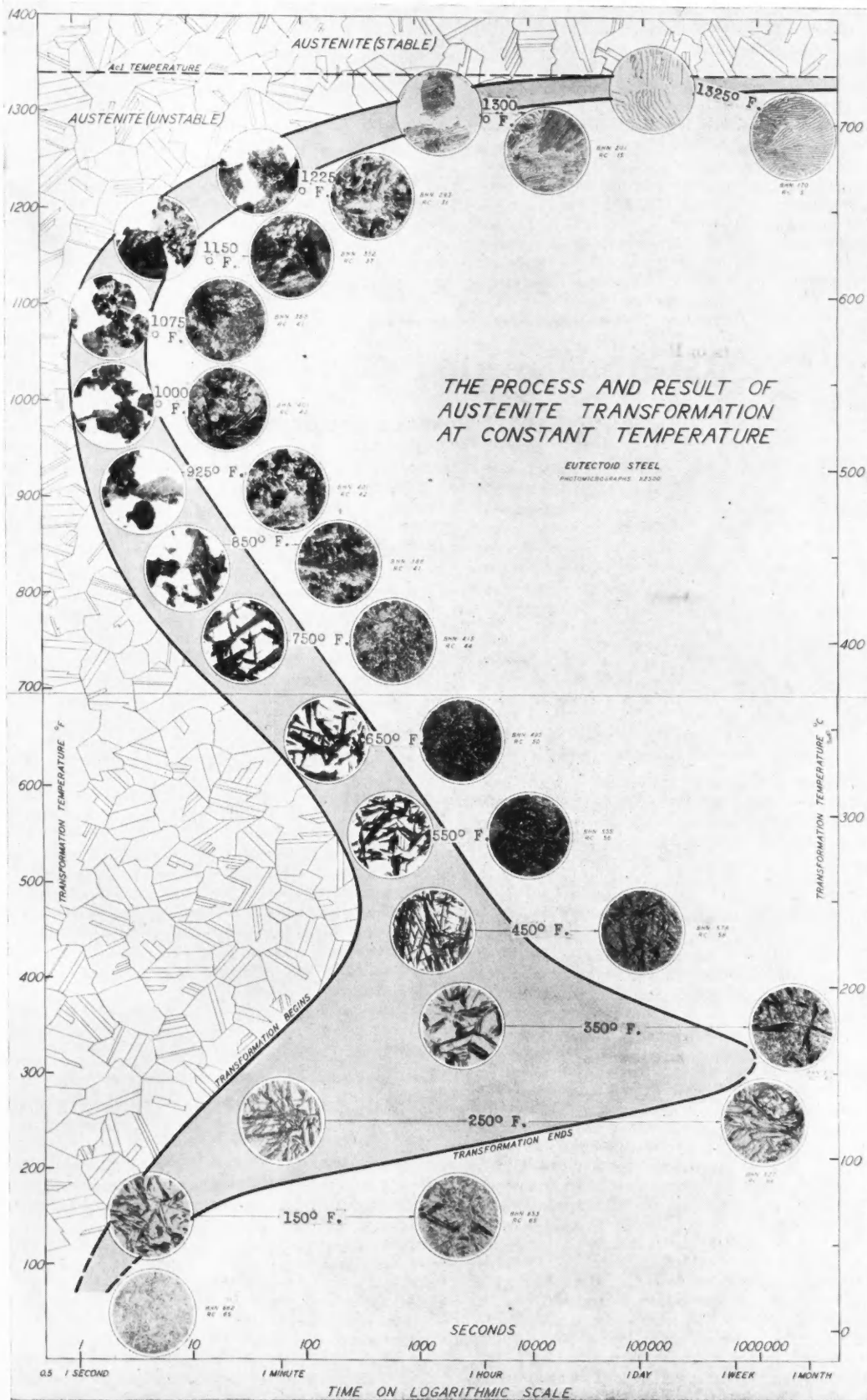


Chart showing the influence of transformation temperature upon the final structure.

limits if the product is to be as uniform from heat to heat as is now demanded.

The assumption that the "chemistry" of a steel is all important has led many consumers to analyse a steel which exactly suited their purpose, and then to demand steel of precisely this composition with respect to the elements commonly determined by analysis. But this has not solved the consumer's problem and has had the disadvantage of leading to a multiplicity of nominal steel compositions, a number which is certainly five times, possibly ten times, as great as it need be to cover every purpose satisfactorily. It would be to the advantage of everyone to lessen the total number of nominal compositions; many of them are now so similar that they can be distinguished definitely only by well-made chemical analyses. A point which illustrates the changing attitude with respect to this "chemistry" is that phosphorus and sulphur

have commonly been regarded as nuisance elements, and in most specifications are limited to 0.05 per cent. or less, although there is little real evidence that, for many purposes at least, such low limits are required. There is no doubt that sulphur or phosphorus may be a nuisance if it is not properly taken into account; yet within recent years comparatively large quantities of sulphur or of phosphorus are being deliberately added to certain grades of steel because they confer some useful property on the steel. It is clear therefore that the rather naive ideas hitherto prevalent on this matter will be modified, as we learn more as to the precise effect of each element, alone and with others, on the properties of a steel properly made and treated. The real effects of the several elements are not, in general, additive; and so there are still large numbers of permutations of compositions and of heat treatments awaiting the careful investigator.

Electrodeposition Conference

Provisional List of Papers

THE first International Conference on Electrodeposition, organised by the Electrodepositors' Technical Society, will be held in London on March 3 and 4. According to the programme Lord Melchett will open the conference at British Industries House, Marble Arch, W.1, on Wednesday, March 3, at 12.15 p.m. The first session (2.30 p.m.-5 p.m.) will be devoted to Electrodeposition Practice Abroad; the second session (7.30 p.m.-10 p.m.), to Electrodeposition of Base Metals. On Thursday, March 4, the third session (10 a.m.-12.30 p.m.) will cover the Properties of Electrodeposits, and the fourth session (2.30 p.m.-5 p.m.), Electrodeposition of Precious Metals. A reception, dinner and dance will be held at the Criterion Restaurant, Piccadilly Circus, W.1, at 7.30 p.m. for 8 p.m.

Scope of the Conference

Papers to be presented at the conference will include: "Nickel Plating in France" (M. Ballay, France); "Degreasing with Alkali Cyanides" (A. Chaybany, France); "Anomalies in the Microstructure of Electrodeposited Metals and their Influence on the Mechanical Properties" (Michel Cymboliste, France); "British Electroplating Practice" (E. J. Dobbs); "Studies in Evaluating the Brightness of Electroplating" (Dr. B. Egeberg, United States); "The Theory of Cathodic Deposits from Complex Salt Solutions" (Professor Ing. Dr. Techn. A. Glazunov, Czechoslovakia); "Zinc Plating" (Dr. A. Kenneth Graham, United States); "American Electroplating Practice" (George B. Hogaboom, United States); "Methods of Producing Adherent Deposits on Nickel and Chromium" (A. W. Hothersall and G. E. Gardam); "Industrial Electrodeposition of Zinc and Cadmium and Laboratory Investigations of these Processes in U.S.S.R." (Professor Dr. N. Isgarisheff, U.S.S.R.); "Comparative Properties of Metallurgical Surfaces Polished by Mechanical and Electrolytic Processes" and "The Application of Electrical Polishing to the Study of Metal Deposits" (M. P. A. Jacquet, France); "Modern Electroplating Machinery" (Dr. John Kronsbein); "Recent Developments in the Electrodeposition of Tin" (D. J. Macnaughtan); "The Crystal Structure of Copper Deposited from Cyanide Solutions" (Professor Arthur Phillips and W. R. Meyer, United States); "Optical Research of Thin Layers" (Professor L. S. Ornstein, Holland); "Modern Developments in the Electrodeposition of Gold" (H. W. J. Pope); "Contribution to the Study of the Throwing Power of Electrolytic Baths" (Professor Albert Portevin, France); "Chromium Plating from Non-Chromic Acid Solutions with Chromium Anodes" (Professor Dr. Ing. Max. Schlöter, Germany); "Deposition of Platinum Group Metals" (Dr. Carl Schumpelt, United States); "History, Development and Application of Cadmium for Electrodeposi-

tion" (Gustaf Soderberg, United States); "German Electroplating Practice" (Dr. Richard Springer, Germany); "Zinc Plating of Strip-Standard Methods of Electrodeposition," "Copper Plating on Textiles" and "Technical Training for Electrodeposition in U.S.S.R. (Director A. M. Yulin, Dr. Kydriatzev and Eng. Shviriaev, U.S.S.R.).

Anodic Coating on Tin

Method of Production

SOME time ago the International Tin Research and Development Council developed a method of producing colourless films on tin by an anodic process. Like the corresponding films on aluminium these films are capable of being dyed in various colours and have decorative possibilities. Mr. D. J. Macnaughtan, director of research, and Dr. R. Kerr have now extended this work and describe in Technical Publication, Series A. No. 48, how black films may be prepared without recourse to dyeing.

The tin or tin alloy article to be coated is made the anode in a hot solution containing trivalent or quadrivalent anions such as phosphates or ferricyanides using high current density. About six minutes' treatment at 90° C. suffices for a satisfactory blue-black coating on an article of simple contour. The decoration is also suitable for tinplate or pewter and the report includes some illustrations of designs in black and white produced on pewter by this method.

Copies of this publication may be obtained, free of charge, from The International Tin Research and Development Council, Manfield House, 378 Strand, London, W.C.2.

Recent Metallurgical Patent

Ferrous Alloys

IN making alloys containing iron or nickel or both, by melting, one or more of the ingredients which is or are liable to oxidise or volatilise or otherwise to be impaired in the melt is or are mixed with two or more substances, one of which is a metallic salt and another or the other ethyl or methyl alcohol or a mixture thereof. Manganese-iron alloys may be made by the use of potassium sulphate and methylated spirit, aluminium-nickel alloys by the use of potassium aluminium sulphate or potassium iron sulphate and methylated spirit, copper-nickel alloys, with or without iron, by the use of calcium nitrate and methylated spirit; in the latter case, the calcium nitrate may be replaced by a mixture of lime and sodium or potassium nitrate. (See Specification 455,434 of F. Leverick).



Metallurgical Section

March 6, 1937

Electrolytic Extraction of Manganese

THE recovery of manganese from domestic ores is presenting a peculiar problem to the United States in that, although large tonnages of manganese are available in various localities, little is sufficiently high grade to compete with imported ores. Most of the 250,000 tons of manganese consumed annually goes into the steel industry in the form of ferro-manganese, which requires a rather high-grade smelting ore. The hydrometallurgy of many of the domestic ores, however, has been developed rather thoroughly, but there has been no satisfactory method for removing the manganese from solution until the electrolysis of manganese-containing solutions was investigated at the National Bureau of Mines (Report of Investigations 3331).

Manganese has a definite tendency to deposit on the cathode as nodular or tree-like growth; the resulting unevenness causes pockets which are subject to oxidation and though the deposit may appear to be completely metallic it is possible that it will have a high oxide content. It has been found, however, that suitable bright metallic manganese can be obtained on the continuous electrolysis of a solution containing 4 molecular proportions of manganous sulphate and 2 molecular proportions of ammonium chloride, and in the presence of a small quantity of sulphur dioxide. Fifty grams of metallic manganese, which analysed 99.71 per cent. manganese, were obtained from such a solution by continuous electrolysis for 72 hours at a current density of 48 ampères per square foot and an average current efficiency of 40 per cent. It was found that ammonium sulphate could be substituted for the ammonium chloride in molecular proportions with equally good results.

Manganese of 99.85 per cent Purity

A complete regenerative system for the electro-deposition of manganese was constructed at the laboratories of the National Bureau of Mines. The electrolyte which contained manganous sulphate and ammonium sulphate was circulated from the catholyte to the anolyte and to a mixing tank, where manganous carbonate (the raw material) was added and reacted to neutralise the partly spent anolyte. The solution then passed to a settling tank and completed the cycle by flowing into the catholyte space. Sheet lead was used for the anodes and sheet iron for the cathode. Deposition for a period of 48 hours, at a current density of 35 ampères per square foot, gave cathodic manganese of 99.85 per cent. purity. The deposit was of dense structure, satisfactorily adherent, and had a reasonably smooth surface; in addition there was no evidence of treeing.

Following this small scale experiment manganese-ore samples were obtained from various localities, a

larger regenerative electrolytic system was constructed, together with a small improvised leaching system, and satisfactory deposits of 99.8 per cent. manganese were obtained on cathodes of 1 square foot area.

Zinc Alloys in Germany

As zinc is now the only metal which Germany produces entirely from domestic ores, it is used extensively instead of imported metals in a number of alloys intended to replace brass and bronze. The availability of large quantities of the 99.99 per cent. grade has created favourable conditions for the production of zinc alloys, since this metal is particularly sensitive to even minute quantities of certain impurities and the properties of its alloys are dependent to a remarkable degree on the purity of the zinc which is used. The most important of the new alloys is "Geische ZL2," with 4 per cent. of aluminium and 1 to 1.5 per cent. of copper. It is shaped by die-casting, but may also be cast in sand or iron mould. Another alloy, "Geische ZL3," with 4 per cent. of aluminium and 0.5 per cent. of copper, lends itself to pressing and drawing, and corresponds in its properties to rolled brass.

The Metallgesellschaft A.G., of Frankfurt-on-Main, produces, under an American licence, a series of zinc alloys called "Zamak," which contains a small proportion of magnesium. "Zamak 5" contains 0.02 to 0.05 per cent. of magnesium, 1 per cent. of copper, and 4 per cent. of aluminium, the balance being zinc of high purity. This alloy is usually die-cast, but may be cast in sand or iron moulds. It has a tensile strength of 22 to 25 kilograms per square millimeter, 90 to 100° Brinell hardness, but only 1 to 2 per cent. elongation. "Zamak 10," an alloy of the same series, shows a greater strength and may be used for castings with complicated cross sections. These Zamak alloys have become a notable substitute material.

Properties of Silver

Renewed interest in silver as an engineering material is a natural consequence of its rather remarkable physical properties. For many years silver has been a convenient material for physicists to use in their observations of the workings of physical laws, and much information has been accumulated in this way. The increasing interest in the metal has created a demand for this accumulated information on its physical properties; data, however, is widely scattered in the technical literature. By a co-operative arrangement with a group of eight of the leading silver producing companies of the United States, the National Bureau of Standards

has, therefore, made a survey of the available information and has assembled it into a usable form. Much information hitherto unpublished is included in this new publication, "Silver: Its Properties and Industrial Uses" (Circular C.412). Divided into three parts, the first deals with the physical, chemical and technological properties of the pure metal; the second part presents the available data on a number of the commercially important alloys of silver with base metals; and the third part discusses industrial uses, classified as electrical, chemical, and bactericidal. A comprehensive bibliography, citing the original sources of information, is appended to each section. The publication is obtainable from the Superintendent of Documents, Government Printing Office, Washington, at a cost of 10 cents.

Copper Production in Sweden

THERE are now prospects for a greater production of copper in Sweden, because considerable deposits of ore in the Skelleftea district in the northern part of the country are being investigated. These deposits cover an area about 55,000 square metres, including the Boliden deposits which amount to about 10,000 square metres. The Laver mine, owned and operated by the Boliden Mining Co., now produces about 2,000 tons of copper per year, and will be in full operation during the current year. The ore consists chiefly of copper pyrites, but carries low silver and gold values. Concentrates are transported by rail to the smelting works at Ronnskar, near Skelleftea. It is expected that the Laver mine will soon be capable of producing 150,000 tons of ore annually. The ore reserves are estimated to be sufficient for ten years. During the sixteenth and seventeenth centuries Sweden produced about 3,000 tons of copper annually, mainly at Falun. Much copper was exported during these early days, but Sweden now depends largely on foreign supplies. The imports of crude copper have increased from 16,000 tons per year in 1927 to 34,700 tons in 1934.

New Analytical Technique for Antimony

A RAPID method for the determination of antimony in lead-rich alloys has been recently described by Mr. K. Stanford and Mr. D. C. M. Adamson ("Analyst," 1937, 62, 23). With Low's original method, that of digestion in concentrated sulphuric acid followed by titration with potassium permanganate in the presence of hydrochloric acid, antimony can be adsorbed by the lead sulphate, which is precipitated when the digest is diluted. To dissolve the alloy in sulphuric acid a long digestion is generally necessary, the time required varying with the particle size of the alloy, and this favours adsorption. The new method, however, avoids this difficulty of solution, with its attendant dangers of adsorption, by fusing the alloy intimately mixed with potassium bisulphate, the reaction between the alloy and bisulphate being complete in three to four minutes, when it gives a homogeneous melt which can be readily extracted with dilute hydrochloric and sulphuric acids. The resulting solution is then titrated in the cold state, with standard permanganate solution.

In practice 1 gram of the alloy is intimately mixed with 5 grams of potassium bisulphate in a porcelain crucible, gently heated. The reaction is fairly vigorous and spattering may occur in the early stages, but with

care it is unnecessary to cover the crucible with a lid. The temperature is then raised to give a homogeneous melt, which with antimony alone is clear, but with alloys is white and opaque. While the crucible is cooling, a mixture of 10 c.c. of conc. hydrochloric acid, 30 c.c. of conc. sulphuric acid and 200 c.c. of water is prepared in a beaker, and the crucible and contents are immersed. When the melt is detached, the crucible is removed and rinsed, and the solution is then boiled for a few minutes, cooled to 5°-10° C., and titrated with potassium permanganate solution which has been standardised with sodium oxalate. The end-points are apparent for half-a-minute, but this period can be increased to three or four minutes if the bulk of the solution titrated be increased to 350 c.c. Alternatively, the solution may be titrated at about 60° C. with potassium permanganate solution, a few drops of 0.05 per cent. methyl orange solution being added as an indicator.

Tin has no effect on this new method as regards the results obtained, but its presence tends to increase the viscosity of the melt, and in amounts greater than 50 per cent. it renders fusion difficult. For alloys containing tin it is, therefore, advisable to increase the amount of potassium bisulphate to 10 grams.

Influence of Vanadium on Steels

VANADIUM, when added to nickel-chromium, or nickel-chromium-molybdenum steels, in quantities exceeding 0.1 per cent. has a marked influence in maintaining almost constant the mechanical properties obtained by tempering the hardened steel within the range of 500-650° C. The reason for this, viz., the retention of vanadium carbide in solution in the alpha-iron formed at the gamma to alpha transformation, and its subsequent precipitation on reheating, has already been discussed by Mr. H. H. Abram, of the Research Department, Woolwich ("Journal of the Iron and Steel Institute," 1934, No. 11, p. 351.).

Vanadium carbide is dissolved in gamma-iron less readily than iron carbide, and steel in which some of the carbon is combined with vanadium does not attain its full hardness when quenched from the usual temperature. If, however, the hardening temperature is raised and more of the vanadium carbide dissolved, higher hardness is obtained on quenching, states Mr. Abram in a more recent contribution to the subject (Iron and Steel Institute, September, 1936). Any deduction as to the maximum useful vanadium content in these steels is complicated by the fact that attainment of the full hardening effect of the vanadium is dependent on the use of a high initial temperature of cooling in air or oil. On the other hand, a hardening temperature above 900° C. is usually accompanied by serious practical disadvantages, and in the steels under consideration it also entailed a lowering of the limit of proportionality and the notched bar impact figure, though deleterious mechanical properties were not so pronounced as in carbon-vanadium steels.

All the steels consisted of uniform sorbite, and the austenitic grain size was not greatly affected by an increase in hardening temperature to 950° C. The results obtained indicate that if the hardening temperature is limited to 900° C., the most suitable vanadium content in nickel-chromium and nickel-chromium-molybdenum steels of the types investigated is 0.15 to 0.25 per cent.

The Electrodeposition of Gold

Variations in the Colour of the Deposit

BEYOND certain stereotyped formulae very little has been published on the technology of gold plating, said Mr. H. W. J. Pope, of Baker Platinum, Ltd., in a paper presented at the First International Electrodeposition Conference, organised by the Electrodepositors' Technical Society, at British Industries House, London, March 3-4. This is probably due to there being but little fundamental change in the methods used. Basically, the electrolyte has remained the same, and the main improvements are in the equipment, source of current, etc. Even to-day the average gilding plant is such, that if a plater of 20-30 years ago were to be set to work with it, he would find no difficulty in procuring results, so familiar would the process be.

Some observers may conclude from this statement, continued Mr. Pope, that the gold plating processes were in such a state of efficiency at the time of their inception that few improvements could be made. The demands of the jewellery trade, however, have not engendered any fundamental research for improvements in electro-gilding. This is mainly due to the fact that as hitherto jewellery has brought a large margin of profit, costs have not been studied, and consequently as long as satisfactory results were being produced from processes the economics were not considered. Rather than acting as a deterrent the present high price of gold has had a stimulating effect upon the processes for electro-depositing gold and its alloys, which produce the permanent and lustrous colours of gold and its alloys without heavy increase in cost, compared with solid gold.

Practically all gold solutions are of the cyanide type, containing alkali, a reducing agent and some phosphate. At first the general opinion was that the main function of the phosphate was that of a conducting salt, but subsequent researches show that in addition a complex salt is formed which keeps the metallic ions at a low value, so permitting the production of a denser deposit. In general, it may be said that the present state of gold electrodeposition is analogous to that of the nickel process prior to Watts' discovery of hot nickel baths, and the main points occupying the attention of research workers are variations of deposit colour, carat plating, quantity output and maintenance of solutions with insoluble and soluble anodes.

Colour of Deposit

The main difficulty with which the research worker is faced in producing a range of colour products is the enormous variety which exist. Despite growing standardisation of products in most industries the jewellery trade is one upon which it has encroached the least, consequently, the individual taste of the craftsman is still reflected upon his work, and this is apparent in the very wide range of colours which are called for. For the layman it may be somewhat difficult to discern the difference between the colours, for instance, where a yellow gold will become a green and a green become a red.

Generally, the variation of colour of deposit is obtained by the introduction of a base metal salt into the electrolyte. For instance, a trace of copper will produce a colour associated with the red golds, whilst a cadmium addition gives the characteristic colour of green golds, in a better manner than does a small addition of silver salt. Zinc is sometimes added to lighten the colour shade. However, this method of producing colour deposits has an economic drawback, for the resultant deposit is practically fine gold, correspondingly expensive. Fine gold is exceedingly soft and scratches easily, and fine gold deposits possess this short-coming to a marked degree. Rather does this defect seem more apparent when the gold is plated on to a harder base metal, due no doubt, to the anvil effect of this hard metal, as compared with the cushion effect of a base metal which is as soft, or softer than the deposit.

Therefore, in spite of the fact that plated metals are harder, a carat alloy is preferable except where the deposit is required for corrosion resistance, as on surgical and scientific instruments and also for non-resistant decorative films.

It is for this reason that rolled gold plate has met with such success, but this material has its shortcomings. Cut edges expose the base metal, which after a short period corrodes and becomes very unsightly, outstanding examples being cheap spectacle frames and wristlets. A further limitation of this metal is that its working properties are very restricted. If a uniform thickness of gold has to be maintained it is most noticeable in drawn and beaten forms. The obvious remedy for this is gold alloy deposition.

Other methods for altering the colour of deposits are to increase the free cyanide content, or reduce the current density. Both of these measures are effective in lightening the colour, but it is obvious that the control is too variable, the result depending a great deal upon the operator's skill. It is these drawbacks in colour plating that have led to the investigation of true alloy deposition of gold, this being really, "plating to carat." Fine gold being 24 ct., 18 ct. means that 24 parts of the alloy contain 18 parts fine gold, the balance being made up of base metal.

Carat Plating

Earlier experiments indicated very definitely that the ratio between gold and the alloying base metal in the electrolyte is not the same as the ratio in the deposit. This is due to the fact that gold deposits at the lowest potential in preference to base metals, therefore, unless certain precautions are taken, the solution nearest the cathode will be rapidly depleted of its gold content, and the cathode potential will rise to that of the next base metal, which deposits on top of the first gold layer and the resultant deposit consists of strata of two or more metals. This behaviour involves difficulties in the control of the solution, but the problem has been carefully studied and has now been fairly well overcome.

To produce a deposit having the composition of 18 carat green gold, the following formula gives satisfactory and consistent results:—

Au as NaAu(CN) ₂	...	...	2.00	grammes	per	litre.
Ag as NaAg(CN) ₂	...	...	0.75	"	"	"
NaCN Free	...	...	4.00	"	"	"
Na ₂ CO ₃ anhydrous	...	...	5.00	"	"	"
Na ₂ PO ₄	...	...	20.00	"	"	"
K ₂ SO ₃	...	...	5.00	"	"	"

This solution is prepared with distilled water, is worked hot, and at a low current density. The deposit is exceedingly smooth and of fine texture, only the minimum amount of buffing being required to produce a brilliant permanent lustre. The throw, as would be anticipated with cyanide solutions, is good. The bath is self-replenishing from anodes; as regards metal content, periodic adjustments calculated from simple test results are requisite for the cyanide and sulphuric contents. A redder colour may be obtained by replacing the silver with copper.

Hitherto, gold baths have been notoriously short lived when compared with, say, nickel, copper and chromium electrolytes, and in the researches on alloy deposition particular attention has been paid to means of producing a suitable solution which can be worked either with soluble or insoluble anodes, and replenished from time to time without premature discarding.

The value of such a solution is apparent in reducing waste, facilitating recovery and reducing spoilage, due to the irregular deposits produced from unstable solutions. Naturally it is optimistic to expect that an electrolyte which con-

tains complex metal ions will run indefinitely without some form of control. Control of the "free cyanide" is well known, the method being the titration of the solution with silver nitrate, using potassium iodide as an internal indicator. However, remarkable results in the direction of long life have been obtained by the control of the oxidation susceptibilities of the bath, and as a result of maintaining definite values in this respect, fine gold plating baths have been in constant use for many months.

For example, a gold bath, 4 litres in volume, used for heavy weight deposition by the barrel plating method, has had over 100 oz. of gold plated through the original electrolyte during 12 months, and the bath is still in perfect working order. The drag-out losses are kept to a very low figure indeed, consequently, the extended life of this bath is not due to replenishment compensating the drag-out loss. All told, 4,800,000 pieces have passed through this bath and every one has been plated to a predetermined gold content, this being 8 per cent. or 10 per cent. of the weight of the object. The final dimensions have to be within limits of 0.0005 inch, and the gold must be dense and adherent and not affected when

heated to a temperature of 850° C. The fact that the percentage of rejects is below 0.1 per cent. is an adequate test of the efficiency of the bath. Routine control ensures that the cathode and anode efficiencies are maintained at constant values, determining the quantity deposition against a "time current" factor.

Formerly the method of estimating the gold in cyanide or cyanide solutions was to take up in concentrated acid to destroy the cyanide, and then to precipitate the gold by one of the many known methods. A simpler method is to fuse the salt or evaporated solution with potassium bisulphate, when the gold is precipitated, and, after dilution with distilled water, to filter off, ignite and weigh.

Such is a very brief outline of the salient features in gold plating as it exists to-day. For the future, said Mr. Pope, at the conclusion of his paper, it is fairly safe to predict that the progress of the jewellery trade will result in the demand for gold plating baths, both for the fine metal and alloys, which will run in manner similar to the simple easily controlled base metal baths of to-day, and it is in this field that much research work has been and is now being carried out.

Cast Iron for Enamelling Purposes

The Importance of Checking Analysis

THE bulk of the pig iron as used in foundries for the making of castings suitable for enamelling, is of the soft variety, and is sold by the manufacturers graded to the analysis and fracture, said Mr. G. M. Logan, in a paper read before a recent meeting of the Scottish Section of the Institution of Vitreous Enamellers. In order to get the best results it is, therefore, necessary to be thoroughly familiar with the various constituents of the pig iron and to know how they react, and also to have a knowledge of fractures.

The composition of the pig irons entering the foundry may vary widely, and it is necessary to have an analysis of each consignment, and so check up with the manufacturers. The silicon percentages are most important in view of the carbon condition required. The lower the silicon the higher the combined carbon, the closer is the grain and everything being normal the strength increases. The fracture of the pig iron along with the analysis helps very considerably to judge as to the suitability for the different classes of work. In making up a charge for the cupola it is necessary to take into consideration the chemical and physical properties of the irons and to be guided by practical experience.

Effects of Various Constituents

Silicon reduces the capacity of the iron to hold carbide of iron; it is of next importance to the carbon. It pushes out the combined carbon to form free graphite. With low silicon and quick cooling a high combined carbon results. The lower the silicon the higher the total carbon (leaving manganese out of consideration).

2%	Si	} +0.25	3.71%	T.C.	} -0.06
2.25%	"		3.65%	"	
2.5%	"	} +0.25	3.59%	"	} -0.06
2.75%	"		3.53%	"	
3.0%	"	} +0.25	3.47%	"	} -0.06

For every increase of 0.25 per cent. silicon there is a decrease of 0.06 carbon. The total carbon can, however, be very much lower than those given above, but it is evidence of irregular working of the blast furnace, and such irons with the total carbons considerably below normal should be rejected.

The influence of sulphur is quite apparent. It counteracts the action of the silicon. High sulphur in cast iron hardens it. It is 10 times more active than silicon and is customary to allow 0.10 additional silicon for every 0.01 sulphur expected over the usual percentages. The desire is for this additional

silicon to throw out proportionately more graphite. Sulphur decreases fluidity.

The coke used for the melting should be low in volatile sulphur in order to keep the sulphur in the castings at the absolute minimum. If the coke is high in volatile sulphur the increase of sulphur in the finished castings may be considerably increased. It is, therefore, always advisable to purchase coke with a low volatile sulphur content. The condition of the content of sulphur in the coke is the governing factor. It can be high if the sulphur is in the fixed condition (sulphates), but if present as sulphide is most harmful. Over 0.15 per cent. of sulphur makes the metal unsound and forms blow-holes. It is not uniform throughout the cast iron and in some parts it may be twice as much as in others. The action of sulphur depends on its state, and if it is combined with manganese it is comparatively bad, but if with iron it is very objectionable.

The carbon modifies the solubility of the phosphorus in the iron. It also hardens and makes it more brittle in the cold. As the carbon increases the amount of phosphorus which can be held in solid solution decreases, and it is this portion which is in the free condition which makes the metal more brittle. It does not affect the balance between the graphite carbon and the combined carbon, thus differing from the other constituents. Phosphorus should remain practically constant according to the amount calculated. Phosphorus affects the contraction of the metal; it lessens it. Silicon, sulphur, and manganese influence it in the other way through the carbon. Phosphorus has no influence on the combined carbon, and as the phosphorus increases in the metal the total carbon tends to get lower; 15 per cent. of phosphorus gives practically no carbon. But while the phosphorus affects the quantities of the total carbon it does not affect the condition of it. As the carbon increases it increases the dangerous free phosphorus. It increases the fluidity, lowers the melting point and reduces shrinkage.

Graphitic carbon itself in iron does not give softness to the metal; it is there as a mechanical inclusion, and has a weakening effect. Graphite is a weak soft material which is scattered throughout the stronger iron. The iron may as well be hollow where the graphite flakes are. The larger the flakes the greater is the weakness to the metal. The carbon of any iron in the molten state is always in one form—that in simple solution. When the molten iron solidifies, the carbon present may come out as free carbon (graphite) or it may remain

in solid solution, known to foundrymen as "combined carbon." Increase in rate of cooling results in more carbon remaining in the combined state.

The degree of hardness depends on (1) the quantity of combined carbon and its condition, and (2) in a smaller way upon the other elements present. The principal hardening agent in cast iron is the combined carbon. The quantity present in a casting is dependent upon the silicon content and the rate of cooling, for similar pouring temperatures. Provided external influences such as too wet sand, oxidation in melting, etc., do not come into play there should be no difficulty in regulating the combined carbon by a suitable charge of metal.

Manganese and sulphur should be taken together, as the sulphur is that portion which has been left after the action of the manganese on it. It behaves like iron and combines with the carbon to form carbide of manganese and this material gives a greater hardening than carbide of iron. It acts on the iron directly, giving a harder and more brittle material. The manganese must overcome the sulphur before it is free to act thus. It is found present in practically two forms, sulphide of manganese and carbide of manganese. It has a greater affinity for sulphur, carbon and oxygen than for iron. With a high manganese and consequent formation of sulphide of manganese the effect will be to soften.

Typical Cast Irons

When making up a charge for castings to be subjected to an after treatment such as enamelling, and especially in the case of large castings such as baths, care and discretion have to be exercised in the choice of the irons so that the maximum of strength can be obtained, and at the same time the iron of which castings have to be made should be as soft as possible. That is, the combined carbon should be kept as low as possible. The following are analyses of irons recently made:—

	Casting.	Indian.	Scottish.	English.
	1	2	3	4
Iron by difference ..	92.136	91.965	92.111	91.740
Manganese ..	.770	1.360	.810	.680
Silicon ..	2.720	2.560	2.800	2.870
Sulphur ..	.049	.030	.034	.030
Phosphorus ..	.860	.230	.760	1.350
Combined carbon ..	.390	.115	.315	.149
Graphite carbon ..	3.075	3.740	3.170	3.181

Total .. 100.000 100.000 100.000 100.000

(1) Metal cast from a mixture of 2, 3 and 4.

(2) Indian iron.

(3) Scottish pig iron.

(4) English pig iron (lower in phosphorus than usual).

Samples Nos. 2 and 4 were weak irons. The strongest iron was No. 3. The combined carbon, it will be observed in No. 1, is 0.390, the aim always being to keep this if possible under 0.4 per cent., but definitely not to exceed 0.45 per cent., otherwise trouble will result both in the foundry and in the enamelling shop (breakage and warping). If you exceed 0.45 per cent. you are very liable to get distortion or warping in the enamelling process.

Certain classes of castings require a high phosphorus and others a lower phosphorus, but all castings to be enamelled come within the range of 0.8 to 1.2 per cent. phosphorus. The following analyses are recommended:—

No. 1.—For baths, etc.

Silicon ..	2.5 to 2.7%
Sulphur ..	under 0.07%
Phosphorus ..	0.8 to 1.0%
Comb. Carbon ..	not to exceed 0.4 or the utmost limit .45%
Total Carbon ..	in the region of 3½%
Manganese ..	0.8.

No. 2.—For stoves, etc.

Silicon ..	2.5 to 2.75%
Sulphur ..	0.07%
Phosphorus ..	1.0 to 1.2%
Comb. Carbon ..	as low as possible.
Total Carbon ..	not to exceed 3½%
Manganese ..	0.8%.

It is very important when building up the bed of coke in the cupola, that the coke employed is correct both chemically

and physically. The fixed carbon should be over 90 per cent., moisture and ash should be as low as possible. It should also be low in volatile sulphur. Physically, the coke should be strong, and its cellular structure should be regular. Coke which has a close cellular structure requires a stronger blast than a coke which is open in structure. The bed of coke must be strong enough to support the charges without breaking down, and it should be kept to a constant height while melting operations are in progress. When the iron enters the melting zone of the cupola it should pass into the liquid condition as quickly as possible to give economical working and the layers of coke between each charge should be arranged basin shape, so that when the successive charges come into the melting zone the air in the tuyers should always blow on coke and not on the metal, to prevent oxidation.

The aim is to burn the coke to CO₂ in order to get the best and most economical results. It is, however, inadvisable to have all the coke burn to CO₂ as the presence of CO also helps to prevent oxidation of the iron above the melting zone of the furnace. With coal, burning takes place on the surface so combustion does not penetrate it. With coke, however, the inside is burning at the same time, due to its porous nature and a high temperature is thus obtained. Coke with large cells burns more rapidly than one with close cells, and a stronger blast is required to burn the coke with close cells and to sweep away the products of combustion.

In order to prevent the volatile sulphur from the coke combining with the iron, a fair amount of flux is required, and a slag rich in lime prevents largely the sulphur from passing into the iron. The physical and mechanical properties of the coke are more important than the chemical.

The degree of penetration of the blast inward to the centre, depends on the velocity of the air as the fan and blower forces it through the tuyers. The effective tuyer area is determined by the air channels through the fuel bed right at the tuyer opening, and this will always be smaller than the cross section of the tuyer. The real area of air inlet into the coke will be smaller than the smallest area section, but is impossible of determination. There is a definite relationship of tuyer area to the cross section of the cupola. With a 36 in. cupola the sum of the tuyer area to the cross section of the cupola is about one-fifth; with an 84 in. cupola, one-tenth, intermediate sizes running in proportion. The volume of air should be constant irrespective of the pressure. There is no reason why the cupolaman should not use the tuyer that suits him best provided the requirements for, low height and proper proportion of total area to the cross section of the cupola is correct and the blast volume regulated to give the best melting rate for the particular cupola.

Moulding Sands and Mould Facings

A great deal could be said on the subject of moulding sands and so much depends on it. In most factories the selection of sand is left to the individual moulders, whereas it ought to be standardised, and at the present time more than ever owing to the ever increasing number of semi-skilled men being employed. To do this means the installation of elaborate sand conditioning plant, where the sand is delivered to the moulders daily, freshly prepared, mixed, aerated, tempered, etc. It means, however, more or less the mechanising of the moulding shop on mass production lines.

Various types of facings are used on the moulds, the chief of which are plumbago, blacking, terra flake, quartz, etc. For enamelling purposes by the dusting process any of the above can be used if the castings are sandblasted. If, however, they are not to be sandblasted, plumbago, terra flake, and quartz are ruled out, the last two if the percentage is high (when mixed with blacking, etc.), the reason being that these three are liable to give bad adhesion and cause shivering. If, however, the castings are thoroughly blasted there should not be trouble anything above normal.

Castings for liquid enamelling should have a good smooth skin and should be free from pits, blacking marks, etc. It should not be necessary to anneal provided the castings are fresh from the moulding shops.

Institute of Metals

Annual General Meeting

THE 29th annual general meeting of the Institute of Metals will be held in the Hall of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, on March 10 and 11.

On Wednesday, March 10, the report of the council and the report of the honorary treasurer will be presented, and the results of the election of the council for the year 1937-38 and of new members will be declared. Papers to be presented for discussion will include:—Marie L. V. Gayler, "The Theory of Age-Hardening"; E. C. Rollason, "Modern Metal Spraying: Processes and Some Characteristics of the Deposits"; Marie L. V. Gayler, "The Effect of the Addition of Small Percentages of Iron and Silicon to a High Purity of 4 per cent. Copper-Aluminium Alloy"; L. Northcott, "The Effect of Cast Structure on the Rolling Properties of Zinc"; Professor R. S. Hutton and Richard Seligman, "An Aluminium Statue of 1893: Gilbert's Eros"; M. Cook, "Directional Properties in Rolled Brass Strip"; H. J. Gough and D. G. Sopwith, "The Resistance of Some Special Bronzes to Fatigue and Corrosion-Fatigue"; J. McKeown and O. F. Hudson, "Stress-Strain Characteristics of Copper, Silver and Gold"; J. McKeown, "Creep and Lead Alloys. Part I.—Creep of Virgin Lead"; Brinley Jones, M.Met., "A Study in the Metallography and Mechanical Properties of Lead." In the evening the annual dinner will be held at the Trocadero Restaurant, Piccadilly Circus, W.1, at 7 p.m.

On Thursday, March 11, the following papers will be presented for discussion:—W. Hume-Rothery and Peter W. Reynolds, "The Control of Composition in the Application of the Debye-Scherrer Method of X-ray Crystal Analysis to the Study of Alloys"; R. J. M. Payne and J. L. Haughton, "Alloys of Magnesium. Part IV.—The Constitution of the Magnesium-rich Alloys of Magnesium and Silver"; W. Hume-Rothery and Ewart Butchers, "The Solubility of Silver and Gold in Solid Magnesium"; J. L. Haughton and T. H. Schofield, "Alloys of Magnesium. Part V.—The Constitution of the Magnesium-rich Alloys of Magnesium and Cerium"; R. A. Stephen and R. J. Barnes, "The Estimation of Grain-Size in the Region above 10^{-3} cm."; Peter W. Reynolds and W. Hume-Rothery, "The Constitution of Silver-rich Antimony-Silver Alloys."

A series of visits has been arranged in connection with the meeting, two taking place on the day before the annual general meeting, and four on the concluding day of the meeting. On Tuesday, March 9, there will be a visit to the works of Kodak, Ltd., Wealdstone (3 p.m.); members will also assemble at Magnet House, Kingsway, the London headquarters of the General Electric Co., Ltd., for a television demonstration (8.30 p.m.). On Thursday, March 11, there will be visits to the works of the Gramophone Co., Ltd., Hayes, or the Associated Equipment Co., Ltd., Southall (2.45 p.m.); Fry's Die Castings, Ltd., Merton (2.30 p.m.); and the Anchor Brewery of Charrington and Co., Ltd., Mile End Road, E.1 (2.30 p.m.).

International Electrodeposition Conference

Opened by Lord Melchett

REPRESENTATIVES of most of the principal industrial countries of the world attended the first international electrodeposition conference held at British Industries House, London, on Wednesday and Thursday, under the auspices of the Electrodepositors' Technical Society. In the course of four sessions some 28 papers were presented dealing with a wide field of electrodeposition problems. Lord Melchett formally opened the conference on Wednesday morning, the chair being taken by Mr. E. A. Ollard, president of the Electrodepositors' Technical Society.

Lord Melchett expressed his pleasure in renewing his acquaintance with the Society on an occasion which provided such definite proof of the Society's continued progress and prosperity. He recalled the occasion, two years ago, on which he opened the first public exhibition relating exclusively to electrodeposition at the Science Museum—an exhibition which attracted over 100,000 visitors, showing the interest and significance which the art of the electrodepositors had for the general public, and the advanced stage of development which it reached. The present occasion, said Lord Melchett, was one of even greater significance. The council of the Society could justly pride itself on the organisation of an international conference which was the first of its kind to be held anywhere, and in which experts from France, Germany, America and Russia were participating. Moreover, the fact that this first international conference was of British instigation and was being held in Great Britain was, in itself, an indication of how well to the fore this country was in the development of electrodeposition work, both on the research side and in industrial development.

Lord Melchett made reference to the scope of the Society's activities. Since its formation, ten years ago, he said, it had been associated from its inception with the Faraday Society, and had acted as the national technical body for the dissemination of scientific knowledge on all matters relating to electrodeposition. It did this by the issue of an annual journal and technical matter supplied to members at low rates of subscription, and by meetings held at monthly intervals. Lord Melchett paid tribute to the officials and council who had directed the Society's activities, and who, by giving their services freely, had done so much for its work. In welcoming the foreign visitors to the conference, Lord Melchett expressed gratification that so many well-known experts from countries in which electrodeposition had made most immediate progress should have made it their business to be present, and expressed the hope that their stay in this country would be a happy and useful one.

Mr. W. R. MEYER, representing the American Electroplaters' Society, in thanking Lord Melchett for his words of welcome, announced that his Society hoped to arrange a second international conference in the United States in 1939.

A NEW method of preserving foodstuffs, especially perishable goods such as milk, cream and meat, without the aid of refrigeration, is being introduced into South Africa by an Amsterdam company. Mr. Karl Wolf, the agent for the company, has demonstrated the new system to the municipal health authorities. The principle underlying the system is the use of oxygen at high pressure, and it is claimed that milk can be kept perfectly fresh for six to seven months.



Metallurgical Section

April 3, 1937

Combined Smelting for Copper and Manganese

ACCORDING to published work the affinity of manganese for sulphur is greater than that of iron for sulphur, so that if a suitable mixture of compounds of iron, copper and manganese be smelted to form a matte and slag, manganese should concentrate in the matte together with the copper. As fundamental data necessary for a theoretical consideration of the feasibility of this process on the basis of free-energy calculations was lacking, experiments have been carried out at the United States National Bureau of Mines to determine whether it would be a practical procedure for concentrating low-grade domestic ores of manganese.

The experiments consisted in fusing charges made up of rhodochrosite, chalcocite, pyrrhotite, magnetite, and quartz in suitable proportions to form a matte and slag. The manganese content of each of the two phases was then determined by appropriate analytical methods. The results of this work showed definitely that under conditions that obtain during the smelting of copper-bearing minerals to form matte, the affinities of manganese and iron for sulphur are very nearly equal. Under such conditions the respective free energies of solution of the various iron and manganese compounds in the matte and slag would have a considerable effect upon the distribution of manganese between the two phases. Within limits which are feasible in practice the silica content of the slag had little effect upon the manganese distribution. On the other hand, the higher the matte grade the greater was the percentage of manganese in the slag. This effect was particularly marked in the range from 10 to 30 per cent. copper. The manganese content of the matte also increased more rapidly than that of the slag as the total amount of manganese in the charge was increased.

Under the most favourable conditions, however, the percentage of manganese in the matte was just about equal to that in the slag. This would be quite satisfactory if the volume of matte could be made much greater than the volume of slag; but the volume of slag would necessarily be large if concentration of low-grade ores were attempted, and the process was therefore considered unsatisfactory.

Manganese Smelting in Germany

GERMAN manganiferous iron ores usually do not contain more than 30 per cent. of manganese. Ores of this kind may be smelted only to produce spiegeleisen, *i.e.*, pig iron with 10 to 30 per cent. of manganese. In the past, the low-content German manganiferous ores have been reduced at a low temperature that has permitted separation of iron alone in a molten state, whereas the

manganese remained as an oxide in the slag. The resulting slag showed a high content of manganese, but was of little value for production of ferro-manganese on account of the large amount of silica originating from the gangue of the ore. This trouble, however, was overcome by adding limestone, but the production of so much slag, diluting the manganese, made the process uneconomical.

A new process, protected by the German Patent 633,524, produces ferro-manganese from low-content German ore by first smelting the ore into spiegeleisen in a blast furnace by the usual methods. Part of the spiegeleisen is then treated in a basic converter and the other part in an acid converter. The two manganiferous slags obtained each contain 30 to 40 per cent. of manganese and 5 to 10 per cent. of iron, and they are mixed for a blast-furnace charge in such quantities that the acid content (silica) of one part of the charge is neutralised by the basic content (lime) of the other part. The ferro-manganese obtained by smelting this charge is stated to be similar in composition to the product resulting from smelting high-content imported ores. A modification of the process consists in blowing the entire amount of spiegeleisen in an acid converter until about one-half of the manganese passes into the slag. The remainder of the manganese is then slagged out in a basic converter, and the two slags are mixed into a ferro-manganese charge as already described.

Some Complex Magnetic Alloys

A STUDY of the magnetic permeability and stability obtainable in alloys of the Permalloy and Perminvar types, modified by the addition of small amounts of other elements, has recently been published in the "Science Reports of Tohoku Imperial University" (Honda Anniversary Volume, 1936). According to Mr. T. Nishina, "An Investigation of some Magnetic Alloys," in the first (Permalloy) series, an investigation was made of the effect, on initial permeability, of additions of manganese, silicon and cobalt in an alloy of the 78.5 per cent. nickel Permalloy type. A group of alloys containing iron 15-30, nickel 70-85, cobalt 4-0, manganese 1-0, silicon 2-0 per cent. (designated "Super Permalloy No. 1") was developed and it was found that the stability at room temperature was inadequate, but could be obtained in a ternary nickel-iron-chromium composition, *e.g.*, nickel 80.1, iron 16.9, chromium 3.0 per cent. A further increase in initial permeability was obtained by the addition of tin to the nickel-iron-chromium alloy.

A useful composition (designated "Super Permalloy

No. 2") is given as iron 10-60 nickel 40-90, chromium 5-0, tin 0.1-5 per cent.

With a view to securing the combination of magnetic permeability and electrical resistance requisite in alloys for loading of transmission circuits, a study was made of the properties of alloys of the "Super Permalloy No. 1" type, with additions of chromium. A group of alloys showing high values for electrical resistance, together with high permeability at low magnetising forces was found to lie within the range of iron 15-30, nickel 60-80, chromium 15-0, cobalt 4-0, silicon 2-0, manganese 2-0 per cent. Special reference is made to an alloy containing nickel 69.2, iron 19.0, chromium 10.0, cobalt 0.3, silicon 1.0, manganese 0.5 per cent. This group of alloys is named "Resisto-Permalloy." In the nickel-cobalt-iron (Perminvar) series, a study was made of the effect, on initial permeability, of varying proportions of iron and cobalt, with nickel contents of 3 to 13 per cent.; it was found that the range of constancy of permeability of the alloys could be appreciably widened by suitable cold working.

Apparatus designed and used at the Physikalisch-Technische Reichsanstalt (Germany) for the automatic recording of magnetisation curves for ferro-magnetic materials, is described in "Physikalische Zeitschrift," 1937, 38, 1. The curves may be obtained in the course of a few minutes, and the adaptability of the apparatus is such as to render it suitable for study of materials varying from the high-permeability alloys to the permanent magnet steels. Typical curves are shown for Permalloy, silicon steel and nickel-aluminium steel.

Grain Size in Alloy Steel

PAPERS presented at the meetings of the Verein deutscher Eisenhüttenleute during 1936 included one giving "a comprehensive summary of the present position in Germany with reference to the study of grain size in steel and developments connected therewith. The joint authors, Mr. E. Hondremont and Mr. H. Schrader, discussed the causes of "abnormality," coarsening of grain arising from heating, the nature and purpose of the McQuaid-Ehn test, and the variable factors which affect the results obtained by it. A critical review was made on the basis of experimental data on plain, nickel alloy and other alloy steels, of the influence of grain size on workability, machining qualities, toughness, mechanical strength, wear-resistance, creep strength, alternating fatigue strength, susceptibility to temper-brittleness and to ageing, welding quality, and hardenability. The final section of the paper ("Stahl und Eisen," 1936, 56, 1412) relates to control of grain size by modification of composition and production methods, and with the action of aluminium on hardenability of steel and on its sensitivity to over-heating effects.

Gold Extraction by Cyanide

IN his recently published book on "Cyanidation and Concentration of Gold and Silver Ores," Dr. John V. N. Dorr stresses the tremendous stimulus that the epoch-making MacArthur Forrest application of alkaline cyanide solutions had upon the gold-mining industry of forty or fifty years ago. He shows that it is no exaggeration to say its importance to this world-wide industry is comparable in the field of metallurgy only to that of the Bessemer process in the

production of steel. It did not give cheap gold in the way that the Bessemer process produced cheap steel rails, which then gave rise to an enormous extension of railway construction in many parts of the world, but it did lead to a marked increase of gold production by making it economically possible to treat ores which were hitherto considered to be of little or no value at a time when the output of gold indicated a steady and continued decrease. The milling practice for gold ores fifty years ago was crude, with a consequent low recovery of the precious metals. Moreover, the world's supply of gold ores which were rich enough to treat economically at that time was relatively small; except for the use of mercurial amalgamation, which can hardly be considered a chemical reaction, no chemistry was used. Ores averaging under half an ounce per ton, even when not complex, were usually not profitable. Many mines which could be successfully worked to-day were therefore abandoned, most of them permanently. Dr. Dorr states that in South Africa alone the cyanide process increased the gold production from \$6,000 in 1890 to \$6,000,000 in 1893!

Oxide Films and Mechanical Wear

THE effect of oxygen-free atmospheres, *i.e.*, nitrogen and hydrogen, upon the wear of carbon steels has been studied recently by Mr. S. J. Rosenberg at the National Bureau of Standards in the United States. It was found that when certain steels were hardened and subsequently tempered at low temperatures, the rates of wear were comparatively low; the wearing surfaces were smooth and were covered by a thin oxide film, and the abraded particles consisted of Fe_2O_3 and Fe_3O_4 . When these steels were tempered above certain temperatures, the rates of wear were extremely high; the worn surfaces were very rough and bright and the abraded particles were metallic iron. When tested in air all steels were covered with an oxide film and the rates of wear were low.

Lead in Air of Workshops

ACCORDING to the annual report of the Chemical Branch of the Mines Department of Western Australia for 1935, several determinations have been made to determine the amount of lead in the air in workshops where a lead hazard might be supposed to exist. The method adopted was that of drawing the air from a selected point through a layer of cotton wool at the approximate rate of respiration for $4\frac{1}{2}$ hours. The particulate lead retained on the wool was then determined. On a basis of 32 per cent. as the average retention of lead by the lungs, which has been found by other workers for conditions of gentle exercise, the amount of lead which would be inhaled and retained by a worker during a working day (eight hours) was calculated. A limit of two milligrams a day has been put forward by Sir Thomas Legge, late Senior Medical Inspector of Factories in England, as a daily dose of lead which, inhaled as fumes or dust, may in course of years set-up chronic plumbism. The quantities of lead found in four samples taken in workshops and calculated on this basis were 0.8 milligrams in the case of accumulator workshop ("pasting" plates), 0.5 milligrams for battery workshop (casting plates), 0.2 milligrams for printing shop (linotype room), and 0.2 milligrams in the case of a canister workshop (gas-heated solder channel).

Recent Progress in Non-Ferrous Metals Research

29th Annual Meeting of the Institute of Metals

THE 29th annual general meeting of the Institute of Metals was held in London on March 10 and 11, the president, Mr. W. R. Barclay, being in the chair.

According to the report of the Council 1936 was a notable year in many ways, particularly in that the constitution and method of election of the Council was revised and rendered potentially more fully representative of the members, and that a scheme of active co-operation with the American Institution of Mining and Metallurgical Engineers was successfully negotiated. For the first time since 1931, it was possible to record an increase in membership. The growth in the past year—from 2,067 to 2,091—is slight; but there is reason to hope that, as a result both of improved industrial conditions and of certain steps taken to develop the membership, the increase will be greater during 1937.

The scheme approved in March 1936 for the limitation of the maximum period of continuous service on the Council became operative during the past year. As a result, several members who had served on the Council for many years retired, and the vacancies thus created were filled by new members whose fresh outlook has been stimulating and helpful. The presence on the Council of the chairmen of the local sections has been particularly valuable.

The first gathering of members to take place in France was held in Paris, September 14-18, the occasion being the 28th autumn meeting. The meeting opened with the delivery, by Professor P. A. J. Chevenard, of the autumn lecture on "The Scientific Organisation of Works." After the discussion of papers at two morning sessions, visits were paid to works and other places of interest in and around Paris, Rouen, and Havre. The meeting was attended by members from fourteen countries.

Activities of Local Sections

The activities of the six local sections—and of the associated Manchester Metallurgical Society—have been effectively continued throughout the past session. Their requirements and interests have been kept fully before the notice of the Council as a result of the new arrangement whereby each local section chairman has a seat on the Council, and as a result of a round of visits paid to the local sections by the president, who was thus enabled more fully to appreciate the excellent work of the various local committees. A notable feature of the programmes of the sections has been the number of meetings arranged jointly with other bodies, including the Iron and Steel Institute, the Institute of British Foundrymen, the Society of Chemical Industry, the Institution of Automobile Engineers, and the Institution of Engineers and Shipbuilders in Scotland. Visits to works and to the National Physical Laboratory were arranged.

Election of Officers

The following officers were elected for the year 1937-38:—President, W. R. Barclay. Vice-presidents, Eng. Vice-Admiral Sir Robert Dixon and Lieut.-Colonel R. M. Preston. Members of Council, W. T. Griffiths, Stanley Robson, A. J. G. Smout, and D. Stockdale.

A general theory of age-hardening was put forward by Dr. M. L. V. Gayler based on data relating mainly to the age-hardening of alloys of the Duralumin type and of beryllium-copper and silver-copper alloys. Age-hardening was found to take place by two processes: (i) diffusion, and (ii) precipitation, the second overlapping the first. Both processes take place within wide temperature limits which are peculiar to every alloy system, *i.e.*, the "temperature range." The rate at which each process takes place depends, apart from other factors, on the temperature of ageing. The limits of the temperature range are indeterminate, but approximations can be obtained for all practical purposes. If the temperature of

ageing be close to the lower limit, both stages of the age will take place excessively slowly; if the temperature of ageing be close to the upper limit, the first stage will proceed so rapidly that its effect will not be detected. Each of the two processes is characterised by changes in physical properties which will present maxima, or minima, depending on the ageing temperature, the characteristics of the first being gradually replaced by those of the second. The softening which occurs when an alloy is aged at a higher temperature, after being previously aged at a lower temperature, is now explained in the light of the new theory. Curves were given representing the relationships between (i) hardness and duration of ageing, (ii) maximum hardness and temperature of ageing, and (iii) time of attaining maximum hardness and temperature of ageing.

Metallography of Lead

In a study of the metallography and mechanical properties of lead, Mr. Brinley Jones made reference to the tendencies to structural change in rolled lead at ordinary temperatures, stating that mechanical tests can have little significance unless these changes can be controlled or prevented. Experiments dealing with the relationship between deformation, grain growth, and recrystallisation in "as rolled" structures were described, and it was shown that grain growth develops as a result of the critical straining of very refined "as rolled" structures. Lead of "medium" refinement is found to be immune from grain growth and to be affected only by strains severe enough to cause recrystallisation. The structures which result from grain growth and recrystallisation, respectively, after rolling, were shown to be different in type. In the former, the grains are well defined, infrequently twinned, and often associated with intercrystalline cracking; in the latter they are confused and repeatedly twinned. Heavily twinned, recrystallised structures have been found, from experience, to be desirable; reference was made to large-scale experiments dealing with the production, on a commercial basis, of sheets having such structures.

Magnesium Alloys

A paper by Dr. J. L. Haughton and Mr. T. H. Schofield dealt with the constitution of the magnesium-rich alloys of magnesium and cerium. The eutectic point has been found to be at 21 per cent. cerium and 590°C. Magnesium dissolves about 1.6 per cent. cerium at the eutectic temperature and probably less than 0.15 per cent. at 337°C. This paper now constitutes Part V of the investigation of the constitution and mechanical properties of magnesium alloys which is being conducted at the National Physical Laboratory under the direction of Dr. C. H. Desch, F.R.S., for the Metallurgy Research Board of the Department of Scientific and Industrial Research. Recent research on magnesium alloys has shown that the mechanical properties of some alloys at elevated temperatures are improved by the addition of small amounts of cerium. The present work has been carried out to confirm and possibly supplement existing information on the constitution of the cerium-magnesium alloys and has been extended to alloys containing up to about 40 per cent. cerium in order to establish the composition of the eutectic and to confirm the existence of a peritectic reaction.

Dealing with the solubility of silver and gold in solid magnesium Dr. William Hume-Rothery and Mr. Ewart Butchers pointed out that the solid solubility of silver in solid magnesium has been investigated above 300°C, and the solidus and solid solubility curves of the magnesium-rich solid solution have been determined. The maximum solubility of silver in magnesium is 3.9 atomic per cent. (15.3 per cent. by weight) at the eutectic temperature (471°C), and the solubility decreases with decreasing temperature to 0.9 atomic per

cent. (3.9 per cent. by weight) at 300° C. The maximum solubility of gold in solid magnesium is of the order 0.1 atomic per cent. at 576° C., and the solubility decreases with decreasing temperature.

A paper on the creep of lead and lead alloys by Dr. J. McKeown reported tensile creep tests which have been made on specimens of virgin lead in the form of extruded rod, extruded pipe, and extruded cable-sheath. The tests on rod were made at room temperature and at 80° C., while the tests on pipe and cable sheath were made at room temperature only. The effect on the minimum creep rate of the working produced in flattening cable-sheath and in bending and straightening pipes has been investigated, and this effect has been found to be very marked. It has been shown that results obtained from worked samples may give an erroneous impression of the creep characteristic of the unworked, extruded product. In the extruded products the effect of initial grain-size on the minimum creep rate has been investigated, and it has been shown that in extruded virgin lead the larger the initial grain-size the higher the resistance to creep at low stresses.

Corrosion Fatigue of Bronzes

The resistance of some special bronzes to fatigue and corrosion-fatigue was discussed in a joint paper by Dr. H. J. Gough and Mr. D. G. Sopwith. Fatigue and corrosion-fatigue tests on four types of special bronzes were carried out to ascertain the suitability of these materials for special aircraft purposes. The materials tested were: phosphor-bronze, aluminium bronze (10 per cent. aluminium), beryllium bronze (2.25 per cent. beryllium), and Superston L189 bronze. The results showed that the corrosion-fatigue resistance of the bronzes compares favourably with that of stainless steels, the beryllium bronze in particular having the highest corrosion-fatigue resistance of any material so far investigated by the authors. The fatigue resistance in air of Superston is exceptionally high for a non-ferrous material, but the material appears to be highly susceptible to stress-concentration effects.

The constitution of silver-rich antimony-silver alloys was discussed in a joint paper by Mr. Peter W. Reynolds and Dr. William Hume-Rothery, who have accurately determined the liquidus curve of the system silver-antimony in the range 0–25 atomic per cent. of antimony. A new peritectic horizontal is found at 702.5° C., at which temperature the solid solution reacts with the liquid to form the β solid solution which has a close-packed hexagonal structure. The phase boundaries of the α and β solid solutions have been determined accurately at temperatures above 300° C. The general form of the diagram when drawn in terms of electron concentration resembles that of the system silver-tin.

The effect of the addition of small percentages of iron and silicon to a high-purity 4 per cent. copper-aluminium alloy was recorded by Dr. M. L. V. Gayler. It has not been possible to attain a state approaching equilibrium in 4 per cent. copper-aluminium alloys containing up to 0.6 per cent. iron and 1.0 per cent. silicon, under the conditions of casting and subsequent working and heat-treatment described.

Copper, Silver and Gold

In a paper on the stress-strain characteristics of copper, silver, and gold, Dr. J. McKeown and Dr. O. F. Hudson gave a study of the stress-strain characteristics of gold and silver of a very high degree of purity, and also of two coppers, one oxygen-free but containing a small amount of silver (about 0.003 per cent.), the other containing 0.016 per cent. oxygen, but free from silver, both having little more than traces of other impurities. Stress-strain curves were obtained to determine limit of proportionality, 0.01 per cent. proof stress, and Young's modulus.

It is generally considered that copper in the fully-annealed condition has no elastic limit, and the present tests have shown, as was expected, that pure gold and pure silver, when fully annealed, also show no proportionality of stress to strain

in any part of the stress-strain diagram. The elastic properties induced by cold-working were retained in large measure in all three metals after re-heating for short periods at moderately elevated temperatures, when the amount of cold-working (tensile overstrain) had been small. Low-temperature annealing, as used in the test described, did not result in raising the limit of proportionality of pure gold and silver and of oxygen-free and oxygen-containing coppers, to the same extent as in other cases, e.g. other kinds of copper. The tests have shown that, when any of the metals, fine gold, fine silver, oxygen-free and oxygen-containing coppers, has been subjected to a small tensile overstrain, the effect of this small overstrain is evident in the stress-strain characteristics, even after re-heating to relatively high temperatures.

Annealing the overstrained copper tended to restore the value of E lowered by previous overstrain, and by suitable treatment a value of 18.2×10^6 lb./in.² was obtained. Similar effects of re-heating after overstrain were found in the cases of fine gold and of fine silver, although the raising of the modulus by heat-treatment was less marked than in the case of copper. Gold, which had a value of E of 10.3×10^6 lb./in.² when overstrained 5 per cent., gave 11.3×10^6 lb./in.² when re-heated for $\frac{1}{2}$ hr. at 300° C.

Rolling Properties of Zinc

The effect of cast structure on the rolling properties of zinc was the subject of a paper by Dr. L. Northcott. Preliminary work on zinc of 99.99 per cent. purity showed that the casting temperature of ingots cast by the Durville method has little effect on the structure, density, tensile strength, notched-bar impact value, or rolling properties. The examination of ingots made by utilising directional solidification showed that the directional properties of the zinc crystals are such that in columnar form the strength measured in the direction of growth is about four times that at right angles to it. Less pronounced differences were observed in the notched-bar impact values. The selective weakness of the metal along one set of crystal planes was also demonstrated by the tearing action of the cutting tool when machining in certain directions, and resulted in the development of a number of surface cracks.

The connection between cold-working and the absence of columnar crystals was investigated by determining the degree of hot-working necessary to permit subsequent cold-working and correlating the results with the accompanying changes in structure. Provided that the initial hot reduction was not less than about 40 per cent., rolling could be completed satisfactorily in the cold. Hot-rolling was found to be associated with recrystallisation and consequent release of internal stress; recrystallisation was almost complete after about 40 per cent. hot reduction, although much of the cast structure was obliterated after half this amount of reduction. The importance of the equi-axial structure in cold-working was confirmed by tests on specially prepared ingots of equi-axial structure.

Columnar crystal aggregates may be completely cold-rolled if the direction of rolling between light passes is changed according to a crystallographic plan provided that the plane of growth of the crystals is in the rolling plane. No indication has been found that any of the peculiarities of zinc in working are due to boundary effects. Failure in zinc at atmospheric or moderate temperatures takes place by characteristics trans-crystalline cracking in which the cracks tend to occur along the basal plane in any one crystal. This form of failure would appear to be limited to a small range of metals and alloys, possibly mainly of the hexagonal crystal type. The effect is greatly intensified by the powerful tendency of zinc to form large columnar crystals, since in an ingot of rectangular section the columnar crystals developed from one mould face have their directions of weakness in the same planes. The addition of 0.75 per cent. cadmium to the zinc produced a small crystal structure, but increased the recrystallisation temperature so that complete cold-rolling was no longer possible.

Iron and Steel Institute

Forthcoming Annual Meeting in London

THE annual meeting of the Iron and Steel Institute will be held at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1, on Thursday and Friday, April 29 and 30, commencing each day at 10 a.m.

On Thursday, April 29, following the presentation of annual report and statement of accounts for 1936, and the election of new members, the newly-elected President, Mr. Alfred Hutchinson, M.A., B.Sc., will be inducted into the chair. The Bessemer gold medals will then be presented to Colonel N. T. Belaiew and Mon. Aloyse Meyer. Papers and reports to be presented for discussion include:—"Seventh Report on the Heterogeneity of Steel Ingots" (Joint Committee of the Iron and Steel Institute and the British Iron and Steel Federation to the Iron and Steel Industrial Research Council); "The Influence of the Mean Stress of the Cycle on the Resistance of Metals to Corrosion-Fatigue" (H. J. Gough; F.R.S., and D. G. Sopwith; "The Effect of Protective Coatings on the Corrosion-Fatigue Resistance of Steel" (D. G. Sopwith and H. J. Gough, F.R.S.); "Alloy and Fine-Grained Steels for Locomotive Coupling Rods" (H. O'Neill); "Some Experiments on the Influence of Silicon, Phosphorus and Manganese on Nitrogen-Hardening Cast Iron" (J. E. Hurst).

On Friday, April 30, the awards of the Andrew Carnegie Research Scholarships for 1937, the Carnegie gold medal, and the Williams prize will be announced. Papers to be presented for discussion will include:—"The Work of the Coke Research Committee of the Iron and Steel Industrial Research Council" (E. C. Evans and J. M. Ridgion); "A Practical Trial of Roofing Sheets of Copper Steels and other Materials" (Sir Robert Hadfield and S. A. Main); "The Thickness of Oxide Films on Iron" (H. A. Miley); "The Effect of Phosphorus on the Mechanical and Corrosion-Resisting Properties of Low-Alloy Structural Steels" (J. A. Jones); "Method for Testing the Resistance of Stainless Steels to Local Corrosive Attack" (Sven Brenner); "An Investigation of the Iron-Carbon Constitutional Diagram. Part I.—Preliminary Survey of the δ Region" (F. Adcock); "The Allotropy of Iron" (H. Esser); "Alloys of Iron Research. Part XII.—Note on the β Transformation in Manganese-Rich Iron-Manganese Alloys" (Marie L. V. Gayler and C. Wainwright); "Some Properties of Commercial Steel Sheets Containing Copper, Chromium and Phosphorus" (S. C. Britton).

The annual dinner will be held at Grosvenor House, Park Lane, London, W.1, on Thursday, April 29, at 7 for 7.30 p.m. Applications for tickets (price 15s. each, exclusive of wine) should be made not later than April 22.

Institute of Metals

Appeal for Endowment Fund

THE Council of the Institute of Metals are making an appeal for the establishment of an endowment fund having the objects of (a) placing the finances of the Institute on a sound and more permanent basis; (b) assisting the publications of the Institute, and (c) extending the scope of the services offered by the Institute to members and to the non-ferrous metal industries generally.

The Institute of Metals it is pointed out, was founded in the year 1908 at a period when the only body in this country devoted to the scientific and technical aspects of the metallurgy of semi-manufactured metals (*i.e.*, processes subsequent to refining) was the Iron and Steel Institute which, by its constitution, was compelled to confine its activities to iron and its alloys. For more than a generation previously that Institute had rendered important service to the iron and steel industry by inspiring research and publishing its results as well as by fostering the scientific and technical interests of the industry. It was not unnatural, therefore, that some far-sighted scientists and industrialists interested in the non-ferrous metals should have desired to see a similar organisation

exercising an equally beneficial influence in these industries, and although even at that time there existed a strong feeling against the multiplication of technical societies the need for a central body representing non-ferrous interests was so evident and so urgent that the formation of the Institute of Metals was cordially welcomed not only by the considerable number of metallurgists and engineers who formed its original membership, but by other societies.

In the intervening period of nearly thirty years the membership of the Institute of Metals has grown from rather less than 200 to over 2,000, and its influence has widened to an even greater extent. It is now the leading society in Europe for the advancement of science and technology in non-ferrous metals. It is also the principal medium for the reception, discussion and publication of original research work on non-ferrous metals both from universities and from public and private research laboratories throughout the world.

Up to the present the only financial support of the Institute has been that provided by the contribution of its members, the great majority (over eighty per cent.) of whom are salaried employees in managerial or technical positions, and cannot be expected to contribute more than the modest subscription of £3 3s. per annum. Unlike a number of other societies and institutions serving particular branches of industry the Institute of Metals has, with the exceptions of one gift of £1,000 from a former president (Mr. Leonard Sumner), received no capital contributions. Nevertheless, the subscriptions of its members have sufficed to carry on its work for nearly twenty-five years and to place the Institute in the very front-rank of scientific bodies. By wise administration, a small reserve of a few thousand pounds was also accumulated and invested in Government securities, but the wave of depression which struck the world between 1930-35, made these years a period of grave anxiety to the Council, and it was found necessary to draw somewhat heavily on these slender reserves.

In view of this experience the Council feels it imperative that a strong appeal should be made to the non-ferrous industry for funds adequate not only to rectify the present financial position, but also to provide such resources as will ensure a continuous and progressive extension of the Institute's work in the future. They feel that it is only necessary to make the need known to elicit a generous response. An additional income of say £600-£700 per annum from an endowment fund, with a capital sum of not less than £20,000, is suggested.

New Alloys of Tin

Germanium and Beryllium as Alloying Constituents

IN a number of cases the properties of metals are considerably changed by the presence of a small amount of an alloying constituent, for example, by tellurium in lead, nitrogen in iron and bismuth in copper. The alloys formed by the addition to tin of low-melting metals, such as bismuth, antimony, lead, cadmium and zinc, have been studied fairly extensively and now a systematic investigation of the alloys of tin with germanium and with beryllium has been carried out. The work was undertaken for the International Tin Research and Development Council by Professor W. Guertler and M. Pirani at the Institut für Angewandte Metallkunde in Berlin and is now published as Technical Publication, Ser. A, No. 50, "The Systems Tin-Germanium and Tin-Beryllium."

Technique for the preparation of tin-germanium alloys is described. The tin-rich end of the equilibrium diagram of the binary system has been investigated by microscopical examination and thermal analysis. The alloys consist of crystals of germanium in a ground-mass of tin containing 0.1-0.01 per cent. of germanium. Investigation of the mechanical properties shows that the addition of 0.35 per cent. of germanium to tin increases the Brinell hardness by 100 per cent., decreases the ductility by 20 per cent., and decreases the bending strength by 50 per cent. The preparation of tin-beryllium alloys is also described. The addition of 0.2 per cent. of beryllium to tin increases the hardness very slightly.

Some Recent Metallurgical Patents

Pickling Metals

Iron or iron alloy is pickled to provide a blank surface suitable for subsequent enamelling, painting, or metallising, by immersion in an oxidising pickling bath heated to above 50° C which contains an acid and not more than 5 per cent. of a salt the anion of which is different from that of the acid and the cation of which is more electropositive than iron, the initial concentration of the acid being so low that as the pickling proceeds it falls to a value at which hydrolysis occurs, the pickling taking place with precipitation of insoluble basic iron compounds. Fresh acid is added to the bath in such small quantities that hydrolysis is not prevented. A mixture of acids may be employed, the anion of the acid present in largest amount being different from that of the salt. If a mixture of salts is used the anion of the salt present in largest amount must be different from that of the acid and the cations of all the salts must be more electropositive than iron. Examples of pickling baths are (a) 1 per cent. of nitric acid and 2 per cent. of magnesium sulphate, (b) 1 per cent. of hydrochloric acid and 2 per cent. of sodium nitrate, and (c) 1 per cent. of sulphuric acid and 2 per cent. of potassium nitrate. If the iron is heavily rusted the rust may be first removed in a stronger acid solution, *e.g.* 2 per cent. of sulphuric acid and 2 per cent. of potassium nitrate, and the blank pickling then effected in a bath of 0.25 per cent. sulphuric acid and 2 per cent. potassium nitrate. (See Specification 453,704, of W. Heimberger).

Coating Metals

Aluminium or an aluminium alloy is prepared for plating in a known manner and a film of the desired metal not more than 0.01 mm. in thickness is deposited; it is then subjected to treatment whereby the pores in the deposit are sealed, and the electroplating is then continued. The treatment may be effected by chemical oxidation in a bath containing sodium carbonate and potassium chromate. Sealing may also be effected by boiling in distilled water or dipping in a hot solution of nickel acetate or cobalt acetate containing a small amount of boric acid. Alternatively the pores may be filled with insoluble material, *e.g.*, with silica by immersing first in sodium silicate solution and then in acid. The latter methods may also be applied after an oxidation treatment. (See Specification 451,904, of Vereinigte Aluminium-Werke Akt.).

Annealing Alloys

Cast aluminium-magnesium alloys containing 6-14 per cent. of magnesium, with or without up to a total of 3 per cent. of other metals such as manganese, chromium, antimony, calcium, copper, and zinc, are heat treated for the prevention of stress-cracking by being cooled, after the usual solution heat treatment, to 200-350° F and maintained thereat for 5-60 minutes before final cooling to room temperature. The controlled cooling may be effected by immersion in oil or in heated air, and the final cooling in water. The solution treatment may comprise heating at 775-825° F for 1-200 hours. (See Specification 453,849, of Aluminium Ltd.).

Pig-Iron

In the manufacture of pig-iron, in a blast, rocking or rotary furnace, the charge consists of acid iron ores or iron ores rich in sulphur, fuel which may be rich in sulphur and slag-forming substances, such as limestone or dolomite, in such quantity that an easily fusible acid slag, *e.g.*, of the type of a charcoal blast furnace slag is produced. A pig-iron rich in sulphur is obtained and after tapping from the furnace is desulphurised by a basic slag such as one containing sodium oxide or soda or manganese. The slag may be used for the manufacture of paving stones or glassware or can be worked up to obtain the sulphur or sulphur compounds. (See Specification 454,562, of M. Paschke and E. Peetz).

Refining Steel

In a process for the desulphurisation or the simultaneous dephosphorisation and desulphurisation of steel, the molten steel is intermixed so as to obtain a mutual interpenetration with a very oxidising fluid slag containing one or more free bases in large excess, the slag being so highly basic and oxidising and being employed in such quantity that it maintains up to the end of the treatment its strongly basic and oxidising character. The bases used are alkali or alkaline bases such as soda, potash, lime or baryta. The slags may be melted before use or may be added in the solid state to the steel, their fusion being effected wholly or partly by the heat of the steel itself. The intermixing of the steel and the slag may be produced by pouring the steel with great rapidity on the slag or in the basic converter in which the steel is first blown to reduce the phosphorous content, the slag so produced removed and then blown for a very short period with the strongly basic slag. (See Specification 455,042, of Soc. D'Electro-Chimie, d'Electro-Metallurgie, et des Acieries Electriques d'Ugine).

Professional Institutes

A Scheme of Joint Membership

THE Councils of the Iron and Steel Institute and the Institute of Metals announce that, as from January 1, 1937, a scheme of co-operation has been effected between the two institutes. As a first step in this co-operation members of each Institute can become members of the other without formality other than written application. Such members (*i.e.* those already belonging to both Institutes) will pay a combined annual subscription of £5 5s. The amount of the subscriptions previously due has been £3 3s. per annum to each Institute. This provision will apply in the case of the Iron and Steel Institute to subscriptions payable for the year beginning January 1, 1937, and in the case of the Institute of Metals to subscriptions for the year beginning July 1, 1937.

Eligible candidates applying for membership of either institute can simultaneously apply for membership of the other, and in these cases a combined entrance fee of £2 2s. will be payable, this provision also applying to an application for membership of one Institute made within twelve months of an application for membership of the other. Thus it becomes possible to join both institutes for a single payment of £7 7s. instead of £10 10s. as hitherto.

Arrangements have also been made whereby present associates of the Iron and Steel Institute, present student members of the Institute of Metals and new applicants for membership shall be eligible as associates of the Iron and Steel Institute, and as student members of the Institute of Metals up to the age of 26, on payment of a joint annual subscription of £2 2s.; between the ages of 26 and 30 such persons will be eligible as associates of the Iron and Steel Institute (annual subscription £1 1s., no entrance fee) and as members of the Institute of Metals (reduced annual subscription £2 12s. 6d. reduced fee £1 1s.). No transfer fee will be due on taking up full membership of either institute after admission to the associate or student classes. No present member will be entitled to revert to the classes of associate or student.

This scheme for reduced subscriptions is the first step in a more extensive plan of co-operation that is receiving the attention of the two Councils. The present scheme follows one recently completed by the two institutes with the American Institute of Mining and Metallurgical Engineers whereby members, associates and student members may, if under the age of 33, become junior foreign affiliates of the American Institute of Mining and Metallurgical Engineers on specially favourable terms.

Metallurgical Section

May 1, 1937

Magnesium Production in Europe

It is estimated that more than 1,300 tons of magnesium metal were produced by France in 1936, of which about 1,200 tons were used in France. The principal producers are the Compagnie Alais Forges et Camargue, at Saint-Auban, and the Société d'Electrochimie, d'Electrometallurgie et des Acieries Electriques d'Ugine, at Jarrie. The Société Generale du Magnesium is the exclusive fabricating and sales agency for these two firms. The raw materials utilised are carnallite, magnesite and dolomite. Carnallite and dolomite are found in abundance in France, but the magnesite has to be imported from Greece and the Austrian Tyrol. If magnesite or dolomite is used, the carbonate is calcinated in the presence of carbon and in a current of chlorine gas. With carnallite, a directly electrolysable chloride mixture is obtained after a series of dehydrating operations. The anhydrous or nearly anhydrous magnesium chloride is usually mixed with other alkaline chlorides and alkaline earths and treated electrolytically. The electrolytic plant is in the form of a multicellular tank with carbon anodes and iron cathodes, and anodic chlorine for the treatment of the raw material is recovered. Unalloyed magnesium is utilised as a deoxidiser in the treatment of bronze, brass, nickel, silver and nickel alloys, but the largest outlet for the metal is in the manufacture of alloys containing 90 to 98 per cent. magnesium.

This subject of magnesium production in European countries has been investigated by the United States National Bureau of Mines. It is stated that early experiments in the production of metallic magnesium in Germany were carried on at the small chemical plant of Griesheim Elektron, at Griesheim, a suburb of Frankfurt-on-Main. These experiments were financed by the I. G. Farbenindustrie. Eventually the plant was absorbed by the I.G. and employed exclusively for the production of oxyacetylene-welding equipment, and the production of magnesium and magnesium alloys was then transferred to Bitterfeld. The commercial success of the magnesium alloy, known as "Elektron," resulted from research for improving the properties of metallic magnesium; this was difficult because of the affinity of magnesium for nitrogen and oxygen and the deleterious effects of traces of iron. The successful refining of the metal was developed by treatment with a flux composed of carnallite, fluorspar, and magnesia. The iron content in Elektron has now been reduced from 0.016 to 0.005 per cent., and this greatly reduces the susceptibility of the metal to salt-water corrosion.

Metallurgical processes for the production of magnesium utilised carnallite as the raw material until about 1932, when the I. G. Farbenindustrie began using imported magnesite, because of the expensive process of separating the potassium chloride from carnallite and the loss of chlorine when recovering

magnesium from magnesium chloride. The dead-burned magnesite is heated with special grades of carbon in a furnace, and chlorine is passed through the charge. As the reaction is exothermic no extraneous heat is necessary. The resulting magnesium chloride is decomposed electrolytically to produce metallic magnesium and chlorine, the latter being again used for the primary action. Recent reports state that magnesite has now been abandoned in favour of dolomite. Dolomite is said to have become more advantageous by the invention of a successful method for distilling the crude metal as obtained by the thermal reduction of magnesia with coal. The very impure metal powder is then distilled in vacuum, a hydrocarbon oil being used to purify the magnesium at the moment of condensation. The resulting metal granules have a purity of 99.97 per cent.

Germany possesses unlimited quantities of all raw materials used in the production of magnesium, with the exception of magnesite. German magnesite output increased from 5,700 tons in 1933 to 11,000 tons in 1934, and 13,800 tons in 1935. Magnesite imports advanced from 53,400 tons in 1933, to 92,800 tons in 1934, 112,900 tons in 1935, and an estimated 150,000 tons for 1936. In addition to the I. G. Farbenindustrie, the large German potash combine, Wintershall A. G., of Heringen-Wintershall, began producing magnesium in 1934, using carnallite as raw material; in 1935 the output reached 5 tons a day.

Official statistics of German magnesium production have never been revealed. Until 1933, the magnesium and Elektron output of the I. G. Farbenindustrie was estimated to be about 2,000 tons a year. Of the 1934 estimated world production of between 30,000 and 35,000 tons, Germany is credited with the production of about 25,000 tons. Germany's share of the estimated 1935 world output of 50,000 tons is probably 35,000 tons.

The use of magnesium as an alloying metal in Germany is becoming of increasing importance. The principal alloy outlet is Elektron. Magnesium features also in nearly all the important aluminium alloys. The aluminium casting alloy, "Silumin-Gamma," which is produced by the Metallgesellschaft A.G., Frankfurt-on-Main, contains 0.4 per cent. of magnesium. Aluminium alloys of the "magnalium" type contain larger proportions of magnesium, i.e., 2.5 to 10 per cent. The Elektron metal of the I. G. Farbenindustrie, consisting of 85 to 96 per cent. magnesium, 9 to 11 per cent. aluminium, 0.4 to 2.5 per cent. manganese, and 2 to 4 per cent. zinc, varies in physical properties according to actual composition and modifications due to heat treatment. There are four varieties on the market, each intended for a different method of fabrication. In "Elektron giessbar" the important features are casting properties. The composition of

the flux salts in the melting pots, the superheating of the molten metal, and pouring temperature, are important for the production of superior castings. Die casting has been developed to such perfection that parts weighing from 5 to 2,000 grams may be produced with a dimensional accuracy of less than 0.1 millimetre. A casting Elektron metal which lends itself well to heat treatment is "Elektron ausgehartet," containing 90 per cent. magnesium, 9 per cent. aluminium, 0.4 per cent. manganese and no zinc. Other special alloys have been developed for pressing, extruding, forging and rolling. Die forging, however, still offers difficulties, since the metal must be preheated to a very exact temperature. Before any subsequent pressing or drawing of the metal is done, it must be preheated to a temperature between 280° and 300°.

The experimental plant for the production of metallic magnesium at Radenthein, in Austria, is owned by the Austro-American Magnesite Co. It commenced operations about five years ago. Dead-burned magnesite, mixed with coal dust, passes through an electric furnace with three electrodes, and the magnesite is there reduced to magnesium powder. This magnesium powder, together with the coal dust, then passes through a flue into which hydrogen is introduced by jets, then into a cooler and from the cooler to an enclosed briquet machine. The resulting briquets pass into a small electric distillation furnace, from which the magnesium distils in the form of pellets which are collected in a tank filled with oil. The pellets are finally melted into ingots weighing about 1 kg. each. The coal-dust briquets remain intact after the magnesium has been distilled from them.

Metallic magnesium has not been produced in Italy up to the commencement of 1937, but the question of supply has engaged the consideration of the Government. It is probable that there will be a small production in 1937 by the Montecatini concern. This company has 1 million kilowatts of very cheap power available at its plant at Porto Marghera, near Venice, which could be utilised for producing magnesium with raw materials from Tuscany. There is a proposal to erect a small plant in Sardinia, the principal Italian source of magnesite. The derivation of magnesium from the mother waters of certain salt ponds also has been discussed.

The production of metallic magnesium in Norway ceased some years ago, and the magnesium plant of the Norwegian Salt Works, near Bergen, was idle at the commencement of 1937. Production statistics are not available, but it is said that most of the magnesium output was exported to Italy. In Switzerland metallic magnesium is produced by S. A. pour la Fabrication du Magnesium, Lausanne. Magnesite and dolomite are the raw materials consumed in the electrochemical process. The magnesite is imported chiefly from Germany, the Netherlands, and Austria; dolomite, however, is a native product. The production of magnesium metal is approximately 700 tons a year.

Lead Mining in Wales

ARRANGEMENTS have been made for the reopening of certain lead mines in Cardiganshire, Wales. A new company has been formed under the title of Welsh Lead and Zinc Co., Ltd., which will take over an area of over six square miles. The mines and most of the properties on which an option has been secured for a mining

lease are fully developed, and a large amount of ore is ready for immediate treatment. In the past these Welsh mines have produced considerable quantities of lead and zinc, but they have been worked to a shallow depth only. They have been inspected recently on behalf of the interests associated with the new company, and the reports have been encouraging. As lead and zinc are now commanding good prices, the present venture should be capable of development.

Molybdenum in Cast Iron

THE problem of suitable methods for the determination of molybdenum has been greatly accentuated in recent years by the increasing use of this element as an alloy addition to cast iron and steel. Two methods in general use for the determination of molybdenum in cast iron—the lead molybdate method and the sulphide method—have now been supplemented by the use of α -benzoinmonoxime. In a study of all three methods as applied to cast iron ("Analyst," February, 1937, page 107), Mr. E. Taylor-Austin concludes that, although with certain modifications in procedure equally reliable results can be obtained by all the methods, and α -benzoinmonoxime method is the most satisfactory. Incidentally, the time taken for a determination by the latter method is 1½ to 2 hours, as compared with 4 to 5 hours by either of the other methods.

The new α -benzoinmonoxime method possesses several marked advantages over the other two methods. Samples of 3 grams or more may readily be dealt with, whereas the sodium hydroxide separation incorporated in the lead molybdate method is impracticable if more than 2 grams of iron are present. In addition, the new method provides a complete separation, in one operation, of molybdenum from all elements commonly found in cast iron, with the exception of silicon, which is readily removed prior to precipitation; nickel, titanium, phosphorus, manganese and iron do not yield precipitates under any conditions, whilst chromium and vanadium are not precipitated in their reduced states, nor copper in acid solutions. In the lead molybdate method, by contrast, a sodium hydroxide separation is necessary to remove iron; whilst if vanadium is present, special treatment, involving the use of manganese chloride, must be adopted; in the sulphide method the molybdenum is still associated with the other elements of the hydrogen sulphide group, e.g., copper, arsenic, etc. As a third advantage, the use of α -benzoinmonoxime avoids many tedious separations, especially when dealing with complex alloy cast irons.

Phosphor-Copper in Refining Practice

THE German non-ferrous-metals industry, co-operating with the Government four-year plan for raw material self-sufficiency, has introduced phosphor-zinc in place of phosphor-copper in metal refining practices. It is estimated that between 1,000 and 1,500 tons of copper-carrying phosphorus had been used each year in the deoxidation of metal alloys. A special phosphor-zinc alloy, known as "metallophos," has now been placed on the market in the form of handy blocks for the deoxidation of brass, German silver, and similar alloys. The new phosphor-zinc alloy contains 20 to 30 per cent. of phosphorus, whereas the commercial phosphor-copper contains only 10 to 15 per cent. of phosphorus and is not of high purity.

A Modern Laboratory for Metallurgical Research

Investigating the Uses of Nickel and Nickel Alloys

FOR the past fifteen years it has been the policy of the companies now united under the title of the International Nickel Company of Canada, Ltd., and represented in Europe by The Mond Nickel Co., Ltd., to develop their business by means of the industrial application of the results obtained from a careful study of the properties of nickel and its alloys. During this period research has been continually in progress in the companies' own laboratories and has also been stimulated and supported in the laboratories of universities and joint research organisations in various countries.

At the Disposal of Industry

The data obtained from these investigations have been placed freely at the disposal of industry and their use has been assisted by technical staffs having special experience in many branches of industry. By means of correspondence, discussions and demonstrations these staffs assist in the efficient use of nickel-containing materials and in the solution of many industrial problems. The main part of this work is placed in the hands of two research and development departments, one in America and one in Europe. The latter, the Research and Development Department of The Mond Nickel Co., co-operates in a number of countries with bureaux of information which have fully qualified technical staffs and acts, in the majority of cases, as the development organisation in their own countries, conducting a certain amount of research themselves.

To meet the continually increasing demand for more exact data and for improved alloys, occasioned by the growing severity of engineering requirements, however, a central research and development laboratory was built at Birmingham.

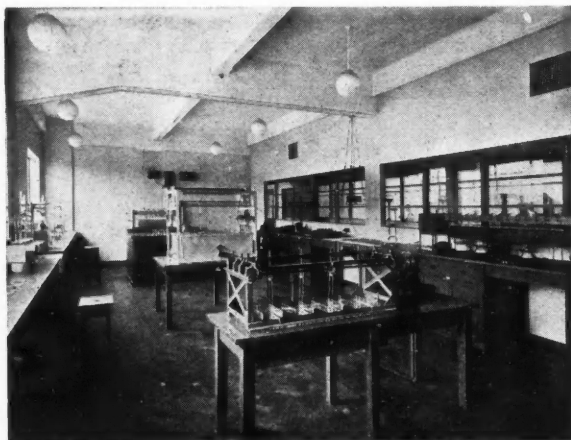
In the heat-treatment laboratory there are two Birlec electric furnaces having hearths 24 in. by 12 in. by 8 in. and 18 in. by

18 in. by 6 in., two large gas-fired furnaces, and a number of small electric furnaces designed for thermal analysis.

From the heat-treatment laboratory there is access to a large laboratory 42 ft. square and 28 ft. high, which has been designed to accommodate equipment for experiments on a semi-works scale. The main stanchions have been made sufficiently strong to carry a 10-ton overhead travelling crane if required in the future. One half of the floor has been laid in reinforced concrete, the other half is laid in concrete paving slabs, so that a minimum of cutting away and making good will be required when heavy equipment is installed. At present a corner of this laboratory is used for melting operations. There is a furnace pit containing a 40 lb. gas-fired



The metallography room equipped with Leitz dilatometer, Hilger spectrograph and Zeiss photo-micrographic outfit.



The main corrosion laboratory. Island sites are occupied by corrosion testing equipment for circular path and alternate immersion methods.

9 in. by 6 in., two large gas-fired furnaces, and a number of small furnaces. Water and oil quenching tanks on castors are provided. The control panels for the heat-treatment furnaces are placed in the adjacent thermal analysis laboratory. These panels consist of temperature controllers, temperature recorders, and time switches. Connections between the furnaces and the controllers are facilitated by holes left in the floors and by wood strips cast into the ceiling of the basement. The thermal analysis laboratory contains a number of potentiometers, a gradient furnace which can be raised and lowered by a small electric motor, and a special thermocouple cali-

furnace, with space for two additional furnaces. There is also an 18 lb. capacity high frequency electric furnace, and a casting pit. It is expected that in the future, melting operations will be undertaken in a portion of the space now used for thermal analysis and heat-treatment. Provision has been made so that the alterations can easily be made, and to this end removable steel partitions have been employed.

On the first floor, one end of the block is occupied by the physical and general laboratories. The physical laboratory contains a Hughes permeameter and other magnetic testing equipment, a variety of resistance bridges, and similar equipment for determinations of physical constants. The general laboratory is primarily intended for experimental work of a special nature which cannot be carried out in the ground floor laboratories, as for example the determination of the effects of gases on metals under conditions of precise control.

Metallographic Investigations

At the other end of the first floor there are metallography, preparation, macro-photography and dark rooms. The metallography room contains a Zeiss photomicrographic outfit, and hand microscopes, together with a Hilger spectrograph and a Leitz universal dilatometer. The last two instruments are located in the metallography room to keep together all photographic work. Provision has been made for a further dark room in the physical laboratory, in which room the spectrograph and dilatometer may be located in the future. Facilities are provided in the metallography laboratory for preparing drawings and for the trimming and dry mounting of photographs. The preparation room contains usual grinding and wet-polishing equipment, and a hood with lead-covered bench

and sinks, and a fan for the removal of fumes. The macro-photography room contains cameras, adjustable stands, spot lights, and enlarger, and in addition is provided with normal dark room facilities. For routine work there are two small dark rooms reached by a single maze entrance; the first room is used for printing and the second for the development of plates.

One end of the second floor contains two rooms at present occupied by equipment for the testing of electrical-resistance and heat-resisting materials. In one of these rooms the work principally carried on is the accelerated life testing of resistance wires, for which there are 60 units for the Bash and Harsch test, and 60 units for testing wires in the form of spirals in refractory formers. Power is obtained from tapped transformers giving voltages from 5 to 110, controlled by two voltage regulators. The second room contains equipment for testing electrical resistance materials under conditions simulating those of service. Tests made in this room include life tests on electric firebars, hot plates, oven and iron elements. For these tests there is a tapped transformer, giving voltages from 5-250. In both rooms timing devices, relays and contactors have been installed so that the elements under test may be switched on and off automatically, and equipment is provided to record the life of the materials under test.

Corrosion Laboratories

The remainder of the second floor is occupied by chemical and corrosion laboratories. The main corrosion laboratory is 40 ft. by 20 ft. and contains specially designed apparatus for alternate immersion, circular path, and jet tests. On the



A view of the general laboratory of the Mond Nickel Co., Ltd.

other side of the corridor there are two laboratories each 20 ft. square, the partition between them being, in fact, two rows of fume chambers placed back to back. One of these rooms is used mainly for corrosion tests involving the development of fumes while the other is used for chemical analysis. Electro-plating is carried on at present in this section of the laboratory, but will later be carried on in a room partitioned off from the spare space at the east end of the block. A balance room, chemical stores, and preparation room are located conveniently near the chemical and corrosion laboratories, while a small room is provided for indoor atmospheric corrosion tests.

The central staircase of the building is continued up to the roof, where there is a penthouse containing two small rooms. One of these is used for the storage of inflammable materials and the other contains a sea water tank, supplying the jet test apparatus in the corrosion room below, the sea water being returned to this tank by an air lift. The roof of the laboratory is flat, and carries corrosion frames which, if desired, may be brought into the penthouse for the examination of the specimens.

In most rooms drainage channels and service channels carrying gas, water, compressed air and electric supplies, have been formed in the floors. Round the walls of the laboratories pipes are exposed, but electrical services are carried in a groove formed in the walls by means of specially cast reinforced concrete channels about 9 in. by 6 in. and covered by asbestos sheets. These channels connect with the ducts so that any electrical supply required can be brought to a point quickly and with a minimum of disturbance. Conduits for lighting and for electric power distribution are in copper, and gas, water and compressed air pipes are also in copper. The drainage channels are formed in glazed earthenware laid in acid-proof cement in a concrete channel lined with acid-resisting asphalt. These channels connect up to Ni-Resist corrosion resisting cast iron pipes which lead the waste to an asphalt-lined sump formed in concrete integral with the basement ceiling.

In each laboratory the gas, water and air pipes are provided with main cocks at the points where they pass out of the vertical ducts, so that the supplies in any room may be cut off without affecting other rooms.

Power Distribution

For the physical and general laboratories special arrangements have been made for power distribution. The switch sockets in these laboratories are connected to plugs on a special distribution board carrying sockets wired for D.C., A.C. and controlled voltage. Other sockets on the board are connected through contactors operated by Leeds Northrup potentiometer controllers. Any socket may be supplied at a moment's notice with electric power from any of these sources and provision has been made for 36 power points on this system.

Generous use is made throughout the laboratory of steel sections embedded in the beams, ceilings, and walls into which T-headed bolts can be inserted for carrying equipment such as motor starters, and galvanometer supports. These inserts permit equipment to be fastened quickly to walls or ceilings and subsequently removed without damage. Except in the chemical laboratory and in the metallography block the benches consist of tiled reinforced concrete slabs with welded steel legs. To provide cupboard and drawer accommodation beneath the benches special steel cabinets have been provided which slide beneath the benches, where they are held by clips. This arrangement gives great flexibility and is particularly useful where, for some special experiment, it may be desirable to place equipment beneath a bench.

Recent Metallurgical Patents

Cast Iron Alloys

Low-carbon cast irons are produced in a cupola which is blown with a blast heated to a high temperature, *e.g.*, 400–700° C., the working of the cupola being regulated so that the melting of the charge, formed mainly of steel scrap with proportions of fuels, and of siliceous and calcareous materials much higher than those normally used, takes place rapidly in a reducing atmosphere and in a zone of small height at a temperature of 1,700–1,800° C. The proportions of carbon used is at least 50 per cent. greater than that normally used, and the addition of limestone is regulated so as to obtain a slag in which the proportion of silica to lime is lower than 1, and the melting temperature of which is much higher than that of ordinary slags produced in cupolas. The cupola used for the process is formed of a metallic cylinder sprinkled externally by the trickling of water, is provided with water-cooled towers and is closed at its top by a charging bell below which is an outlet for the escape of gases. Part of the gases are supplied to an air heater in which the blast is preheated to the high temperature required. The cast-iron produced is deoxidised and desulphurised and the slags may be used for the manufacture of cement. Alloy cast irons may be produced by adding metals such as nickel or chromium to the charge. (See Specification 457,869 of H. Philippon).

Modern Methods of Alloy Steel Analysis

The Problem of Interfering Elements

STEEL analysis now forms one of the highly specialised branches of chemical science, said Mr. B. Bagshawe, of the Brown-Firth Research Laboratories, Sheffield, in a lecture delivered to the Midland Metallurgical Societies at Birmingham on April 1. The task of the chemical pioneers has been a very thankless one, but it is to them that we owe the great developments of the present century which have revolutionised the whole structure of metallurgical analysis and enabled it to emerge from the obscurity which enshrouded it about thirty years ago, and to attain the highly respectable position which it occupies to-day.

Selective Organic Reagents

The particular line along which development has been most marked is a thorough investigation and understanding of the theory of hydrogen ion concentration and the effect of ammonium chloride and ammonium and sodium acetate on the suppression of hydroxyl ion concentration. Along with this development, and the consequent wider knowledge of pH values, there has been evolved not only a series of new oxidation reduction indicators but also a wider understanding of the principles relating to the quantitative separation of elements from closely related members of the same family group. Another important feature has been the development of selective organic reagents to meet the need for reagents of a more or less specific character. So diverse are the possible combinations of elements in modern alloy steel that very often the whole course of the analysis is determined by the particular nature of the alloy under examination. The effect of this is to make ferrous analysis more and more of an individual character and less and less capable of standardised routine treatment, and whilst this may be very admirable from an academic or research point of view, it is not without a serious dislocating effect on the efficient operation of a busy routine laboratory engaged on rapid large-scale production.

The problem of interfering elements is a very real one and is constantly becoming more acute, and it is in this respect that the specific character of some of the organic reagents have been so advantageously exploited. Of these reagents dimethyl glyoxime is perhaps the best known and easily the most important, in fact the discovery of this oxime by Tschugaeff in 1905 ranks as one of the greatest analytical developments of the century. Of the remaining organic reagents, alpha nitroso beta naphthol for cobalt, alpha benzoin oxime for molybdenum and cupferron for titanium and zirconium are perhaps the most valuable.

Determination of Manganese

Coming to a more detailed study of analytical methods, manganese is an element which has undergone comparatively recent modification to provide a method capable of application over a wide range of alloy compositions. The bismuthate method leaves nothing to be desired for the plain carbon and nickel steels and is too well-known to merit more than passing mention. Unfortunately the limitations of this test are such that its direct application to alloy steel is confined within very narrow limits, for while it may be unrivalled for straight carbon steel, it fails signally when applied to steels containing cobalt or anything greater than small amounts of chromium. For stainless steels, the most convenient method is to obtain a sulphuric acid solution of the steel and carry out a zinc oxide separation of iron and chromium from manganese. Manganese can then be determined in an aliquot fraction by the standard bismuthate procedure. Some of the very high nickel steels do not readily dissolve in sulphuric acid solutions and the only satisfactory treatment for these steels consists of solution in mixed hydrochloric and nitric

acid followed by double fuming treatment with sulphuric acid.

Persulphate oxidation in nitric acid solutions followed by arsenite titration is a well-known and largely used routine method, but it is limited to comparatively small amounts of manganese and in addition, depends for its success on empirical standardisation against a known source of manganese. This oxidation is, however, now available in an accurate modified form which also permits the estimation of both chromium and vanadium in the same solution. The advantage of a three-fold method of this type is obvious. Steels containing as much as 3.5 per cent. of chromium can be handled with ease on 2 gram samples, and up to as much as 7.0 per cent. of chromium can be satisfactorily dealt with on one gram samples. Vanadium is without influence on either the chromium or manganese figures, but if present can be determined after completing the chromium test. This is effected by adding ferrous ammonium sulphate sufficient to reduce vanadium to the quadrivalent condition and leave about 1 cc. excess. The excess ferrous salt is then destroyed by the addition of ammonium persulphate solution which has no reoxidising influence on either chromium, manganese or vanadium in cold solutions. After standing for two minutes, vanadium is titrated with N/20 KMnO_4 .

Cobalt is entirely without influence, the only element to interfere being tungsten which is retained in solution as a complex phospho tungstic acid and leads to erratic results. The effect of this element can, however, be eliminated by hydrolytic separation and removal as tungstic oxide prior to the addition of the phospho-sulphuric acid mixture. Another rather novel method for estimating manganese and chromium together, depends upon a combined oxidation of both metals to their highest valence with ammonium persulphate, followed by a selective titration of manganese with standard sodium titrite, after which chromium is determined by completing the titration with FeSO_4 and KMnO_4 .

Chromium in Stainless Steels

The estimation of chromium in the stainless and high chromium heat-resisting steels has been the subject of considerable investigation with the object of speeding up the process to meet the requirements of routine production. In this respect the efficiency of the initial acid solvent is of primary importance, as the time spent on the process is conditioned very largely by the method adopted in obtaining a satisfactory solution of the steel. Most of the straight chromium stainless steels are readily soluble in dilute sulphuric acid, leaving only a carbide residue which is amenable to oxidation treatment with nitric acid. An important point to remember is that complete solution in sulphuric acid must be effected prior to oxidation treatment, otherwise the addition of nitric acid will induce a state of passivity and any further solution will be inhibited. Steels containing upwards of 20 per cent nickel do not respond readily to sulphuric acid attack, and with many of these steels the addition of hydrochloric and nitric acids is the only means of accelerating solution, although the value of this treatment is somewhat discounted by the necessity for a double fuming treatment to ensure removal of chlorides. Solution in a mixture of sulphuric acid and phosphoric acid is on the whole rather quicker than sulphuric acid alone, but the same difficulty with the high nickel and chrome-molybdenum-carbon steels are apparent.

The use of mixed phosphoric and perchloric acid has recently assumed greater importance. Suitable mixtures of these two acids are remarkable solvents for all types of rustless and heat-resisting steel. Decomposition in mixtures of

two volumes phosphoric acid and one volume of perchloric acid is complete in a few minutes and difficult carbides are rapidly and completely decomposed at temperatures between 160° and 190° C., with no danger of reactions of explosive violence. The Vignall method is still the most commonly used in this country in spite of the fact that it is much more time consuming and requires a greater degree of manipulative skill than either the perchloric or persulphate methods. The method is accurate, but a point to bear in mind is that the high chromium steels must be oxidised much more slowly than low chromium steels, otherwise there is a distinct tendency to low results, due presumably to a premature breakdown of potassium permanganate. Although accurate the continued use of this method is not warranted, as the same degree of precision can be obtained much more simply and rapidly by perchloric or persulphate oxidation.

Plain Carbon Steels

Practically all the present day plain carbon steels contain small amounts of accidental chromium from the scrap which is incidental to the process of manufacture. In fact, given a sufficiently sensitive method of detection, traces of the element can be detected in almost any steel. The estimation of such small amounts by the usual volumetric methods are not altogether reliable, especially when less than 0.02 per cent. of the element is present, and in such cases the figure obtained is very often a pure gamble. These very small percentages can be estimated with a remarkable degree of accuracy by a colorimetric method based upon the extremely sensitive colour reaction that dilute acidified chromates given with diphenyl carbazide. The colour produced is an intense violet red, possesses a fair degree of stability and is sensitive to one part of chromium in five million parts of solution. Chromium in steel can be obtained in a form suitable for this test by treatment with sodium peroxide, and removal of the iron by fractional filtration. The reagent also gives colour reactions with salts of mercury, cadmium, magnesium, copper, nickel, molybdenum and vanadium, but of these, mercury, cadmium and magnesium are never found in steel.

Titanium is an element which has recently assumed a much greater importance in steel making due to its use in some of the austenitic nickel chromium steels of the Staybrite type in connection with the prevention of weld decay or intercrystalline corrosion. Many of these steels contain 0.50 to 0.60 per cent. of the element, and occasionally up to one per cent. is present. Previous to its addition to these steels, its use was practically limited to deoxidation and in such cases very little, if any, residual metal remained in the finished product. The estimation of the element in unalloyed steels is very simple and accurately carried out by the well-known colour test based upon the yellow colour of per-titanic acid in peroxidised sulphate solutions. The estimation, unfortunately, is not quite so simple in the high nickel-chromium rustless steels due, not only to the much larger amounts of titanium present, but also to the difficulty of accurately matching the yellow per-titanate colour in the intensely green background due to high concentration of nickel and chromium salts.

Separation of Titanium

The procedure usually adopted with these steels involves a separation of titanium with cupferron which effectively removes both chromium and nickel. This reagent also gives a quantitative precipitation of iron, but provided the test is conducted on a sulphuric acid solution of the steel without oxidation, the titanium reaction is preferential to the iron reaction from ferrous solutions. The reagent is used in the form of a six per cent. aqueous solution, and is added slowly to the ten per cent. sulphuric acid solution of the steel until the precipitate assumes a distinct brown colour indicating the precipitation of iron. This is a sure indication that precipitation of titanium is complete, and providing no further addition of the reagent is made, the precipitation will carry only a relatively small amount of iron. The precipitate is

filtered and washed with cold ten per cent. sulphuric acid, and finally with cold ten per cent. ammonia and ignited. The residue is then fused with potassium bisulphate and the hydrogen peroxide colour test carried out on a sulphuric acid solution of the melt, the iron colour being obliterated by the addition of phosphoric acid.

The colorimetric estimation of copper in steel is based upon the blue amine colour which copper gives in ammoniacal solutions. Copper is very readily obtained in a form suitable for the test by the standard sodium thiosulphate process. Copper sulphide residues obtained from this type of precipitation are invariably contaminated with greater or lesser amounts of iron, but in spite of this many chemists weigh the residue and then determine the amount of iron impurity present and make the necessary allowance. This practice is only suitable for very approximate work, probably due to the indefinite constitution of ignited copper sulphide residues which in practice are very often mixtures of sulphides, sulphates and oxides. It is much more satisfactory to dissolve the impure residue with hydrochloric acid, and after removing the iron with ammonia, determine the copper iodimetrically or colorimetrically based upon the blue amine colour. In the case of molybdenum steels, the bulk of this metal is co-precipitated as sulphide with sodium thiosulphate but is without influence on either the iodimetric or colorimetric test.

Molybdenum in Nickel Chrome Steels

Molybdenum is added to many of the nickel chrome steels in connection with the prevention of temper brittleness. It is also the important constituent of several types of high speed steel. Several excellent methods of determination are available, a choice of the most suitable one to apply being governed from consideration of the type of steel, the amount of molybdenum present, and the possible effect of associated alloying metals. The old standard methods, namely, the lead molybdate and molybdenum sulphide methods are still in general use, but they have been augmented during the last few years by the introduction of the alpha benzoin oxime method and the butyl acetate colorimetric process. These new methods each have their own particular advantages, but it is extremely doubtful if they are superior to the lead molybdate method. The only element which adversely affects this method is vanadium which accompanies molybdenum into the caustic soda filtrate and is co-precipitated as a basic vanadate of lead. Tungsten, of course, interferes in a similar manner, but this element can, if present, be removed prior to the soda separation. With high chromium steels, small amounts of this element may be oxidised in the hot soda solution and pass into the filtrate as chromate. In such an event, the co-precipitation of lead chromate with the molybdenum precipitate can be prevented by treatment with a few drops of sulphurous acid prior to the precipitation of lead molybdate.

The butyl acetate colour test depends upon the colour produced by reduced molybdenum solutions with sodium thiocyanate and follows separation of molybdenum from iron and associated metals by extraction with butyl acetate. The test is operated with about one gram of steel. This method is not in any sense an umpire method, but it is the quickest process known, whilst the precision is sufficient for most routine purposes. The oxime method is rather lengthy in operation, owing to the rather bulky nature of the precipitation which retards filtration, and also to the slow rate of removal of the rather large amounts of organic matter and the necessity for a low ignition temperature. The method is, however, the most satisfactory available means of determining the element in vanadium steel and also in the special 7 per cent. molybdenum high speed steels.

Several excellent methods are available for the determination of the total aluminum content of steel, but the close chemical similarity of this metal with iron, chromium, titanium and several other steel-making elements precludes the use of any one method which is not time consuming.

Metallurgical Section

June 5, 1937

Metallurgy at a London Congress

OVER two hundred papers were contributed to the Congress of the International Association for Testing Materials, held recently in London, and seventy-six of these papers related to metals. The mechanical and chemical behaviour of metals in relation to temperature, especially high temperature, received their due share of attention; another sub-division of the metals group was concerned with the progress of metallography and included microscopy, X-ray examinations, the study of metal surfaces by electron interference, equilibrium diagrams, non-metallic inclusions, the solidification of ingots, and recrystallisation. In addition, there were papers dealing with light metals (aluminium and magnesium) and their alloys, and the workability and wear of metals.

The manner in which an ingot solidifies was explained in great detail by Dr. C. H. Desch, F.R.S., of the Metallurgy Department, National Physical Laboratory. This process of solidification may affect the properties of forged or rolled material made from the ingot in two ways: through the shape and arrangement of the crystals, and by the uneven distribution of the chemical constituents. The two factors are not independent, but are both determined by the solidification process. When molten metal enters the mould, the first effect is usually to produce a large number of nuclei at the surface of contact, giving a layer of small crystals with random orientation. Those that have a favourable direction of growth perpendicular to the cooling surface will then continue to grow and crowd out the remainder. The survivors are the so-called "columnar" crystals. With a thin mould or with very hot metal, the first layer may be remelted, and crystals are not formed again until the temperature of the whole has fallen. The ingot has then no "chilled" layer and columnar crystals start from relatively few nuclei.

In most ingots columnar growth ceases before the centre is reached, and many nuclei appear in the liquid mass, thereby giving rise to an "equiaxed" zone. The causes of this change of habit has been attributed to undercooling in passing from metastable to labile state; to the sudden separation of the ingot from contact with the mould by contraction; to change in the rate of outflow of heat caused by the mould having reached a constant temperature; and to a critical ratio being reached between the volume of metal remaining liquid and the area of the solidifying surface. These processes are the same for an alloy as for a pure metal, but in most alloys some degree of chemical differentiation occurs and this "segregation" profoundly affects the properties of the solid mass. Dr. Desch also gave some interesting information upon the segregation of impurities, which is in evidence in ingots. In spite of the very large amount of experimental material available it is certain that the solidification of ingots is still a controversial subject.

Another notable contribution to this Congress was

that made by Professor G. I. Finch, of the Imperial College of Science and Technology, London. His subject was the study of metal films and surfaces by electron diffraction, which is very important because the electron-diffraction camera opens up the hitherto inaccessible field of sub-microscopic structure and atomic arrangement. With the relative simplicity of the technique, the production of diffraction effects of sufficient intensity to be visible in the fluorescent screen and recorded photographically, and an accuracy comparable with that of X-rays, this new research tool is destined to be of inestimable value in metallography. The surface, or rather the skin of a depth elastically accessible to the electron beam, may be available either as a detached film or *in situ* on a massive sub-strate. In the former case the specimen is traversed by the monochromatic electron beam, and the angles, determined by the electron wave-length and the atomic arrangements within the film, which the diffracted rays make with the incident beam are photographically recorded at a known distance from the specimen. Where the surface film is not detached, it is examined with the beam at grazing incidence ("reflection"); true reflection in the X-ray sense, however, occurs when the beam grazes a surface of atomic smoothness, for example, the undamaged cleavage face of a crystal.

The mode of preparation of a metal film may have a profound effect upon both size and arrangement of its crystals. In beaten or rolled foils these are more or less highly orientated, and often form a "fibre" structure, as if the original crystals in yielding to crushing strain had first become arranged with similar zone axes pointing in some preferred direction and had then, whilst changing their external shape, continued to resist the breaking-up of the coherent crystal structure. In electro-deposits the orientation is determined partly by the crystal system, and to a lesser extent by the deposition conditions. Most electro-deposits are crystalline, but both amorphous and well-crystallised antimony films have been obtained, whilst so far arsenic and tellurium deposits have always been amorphous.

Metal films which have been sputtered or evaporated on to a smooth surface like a polished glass disc often appear optically perfectly smooth and of homogeneous texture under the microscope. Nevertheless, they invariably yield "reflection" patterns, sometimes with the complete semi-circles characteristic of the polycrystalline condition, with the crystals unorientated and projecting like minute spikes above the general level of the film. Sputtered platinum films are often active promoters of the combustion of hydrogen. Small crystal size appears to be favourable; with decay in activity during their catalytic life the crystals grow larger. Chemically-deposited metal films and mirrors have so far been found to be crystalline; as also are those formed by evaporation of colloidal solutions of the more noble metals.

According to Professor Finch, electron diffraction has already won a position for itself alongside X-rays and the microscope. Each covers its own field and each is complementary to the other. It is evident, however, that a realisation of the full advantages of electron diffraction and of the older methods in advancing our knowledge of metallography must lie in their future co-operation.

Some recent developments in magnesium alloys which were reported upon by Dr. J. L. Haughton, of the Metallurgy Department, National Physical Laboratory, were prefaced by the remark that magnesium was first isolated in 1808 and was first produced on a commercial scale fifty years later, but it was not until about ninety years after its isolation that it was used for the manufacture of alloys. Until quite recently these alloys could be divided into two groups: those based on the aluminium-magnesium series and those with manganese as the chief addition. In the former case the aluminium content ranged from 3.5 per cent. to 10 per cent., with zinc generally in addition up to 3.5 per cent., and possibly a small amount of manganese is usually added to give increased resistance to corrosion. The second group consists of magnesium, to which about 2.5 per cent. of manganese is added, with or without small quantities of other elements. During the last two or three years, however, several new alloys have been developed. In some of these aluminium is still the chief addition, an alloy containing 8 per cent. aluminium and 8 per cent. cadmium, for instance, combines reasonable strength with good ductility. In a rather more interesting series, silver is added. A magnesium alloy which contains 8.5 per cent. of aluminium and 2.5 per cent. of silver, has also small quantities of manganese and calcium, the former to reduce corrosion and the latter to check burning and scaling during casting and annealing.

Magnesium and many of its alloys lose strength very rapidly as the temperature is raised. This makes such alloys useless for engine parts which have to run at high temperatures, *i.e.*, pistons for internal combustion engines. A considerable amount of work has therefore been undertaken to find alloys which retain an appreciable proportion of their strength at temperatures up to 300° C. One of the most satisfactory alloys yet obtained to meet these conditions contains 10 per cent. of cerium and about 1.5 each of cobalt and manganese.

Determination of Sulphur in Steels

THE existing methods for the determination of sulphur in plain and alloy steel by combustion suggest that in all cases insufficient attention is paid to the details of the procedures. Mr. C. H. Hale and Mr. W. F. Muchlberg (*"Ind. Eng. Chem., Anal. Edit., September, 1936"*), have found that a minimum temperature of 1,200° C. is necessary for the removal of all the sulphur from plain steels, while for alloy steels a temperature as high as 1,450° C. may be required. The use of alumina as a bedding in the combustion boats leads to low results; the authors therefore use no bedding material at all, and discard the boats immediately after use. They claim that the best type of boat is unglazed porcelain, since ordinary fireclay boats absorb sulphur. The use of a plug to retain any iron oxide dust is also abandoned, as it retains sulphur. The exit end of the combustion tube is maintained at a temperature of not less than 200° C. to prevent the absorption of sulphur

trioxide, and a ground-glass joint is employed instead of a rubber bung at this point. The issuing sulphur vapours are absorbed in neutral hydrogen peroxide solution, and a glass frit is used to render the absorption of sulphur trioxide complete. The estimation is completed by titrating the resulting sulphuric acid with 0.01 N. sodium hydroxide solution. An accuracy of 0.0005 per cent. sulphur is claimed for samples weighing 1.6 gm. The time occupied for the determination is 15 minutes.

Metals and Lubricating Oils

THE corrosion of copper, lead and tin, and the influence of these metals upon the deterioration of commercial lubricating oils, has been recently studied by Mr. P. J. Haringhuizen and Mr. D. A. Was, at the University of Utrecht, and the results of these investigations have been published by the International Tin Research and Development Council. Deterioration was caused by heating samples of oils in glass basins for periods of two months at a temperature in the neighbourhood of that occurring in practice. Thin films of the various metals under test were produced on glass plates by evaporation under high vacuum and these films were immersed in the oil during the test period. The films were so thin that they were nearly transparent, and the effect of corrosion in thinning the films increased their transparency so that this property could be used conveniently as a measure of the corrosion which had taken place. It was found that the viscosity, surface tension and the acidity of the oils are not influenced by the metal, but sludge formation is strongly stimulated in the presence of copper wherever tin and lead had the opposite effect. Copper was strongly attacked, but tin and lead were protected by the film of reaction products.

Corrosion Tests on Stainless Steels

SEVERAL methods have been proposed for testing stainless steels, some of which are embodied in specifications for these materials. Three methods recently investigated at the United States National Bureau of Standards in connection with the welding of stainless steel containing about 0.06 per cent. of carbon, are reported in the *"Journal of Research,"* January, 1937. A solution of copper sulphate in sulphuric acid did not noticeably attack either plate or weld metal which had been heated, although this reagent has been reported to cause intergranular corrosion in stainless steels of higher carbon content. Concentrated nitric acid was found to attack carbides which had been localised at the grain boundaries. The acid destroyed the cohesion between the grains by dissolving or decomposing the carbides. This type of attack was found only in plate metal which had been heated to 650° C. and which contained carbides localised at the grain boundaries. Carbides in weld metal were usually found in areas of ferrite and not in the grain boundaries, regardless of heat treatment; consequently the attack by nitric acid on weld metal was slight. Hydrochloric acid diluted with an equal volume of water attacked the plate metal severely. Heat treatment of the plate did not appreciably change this rate of attack. Weld metal that was not treated was attacked at approximately the same rate as plate metal. After annealing at either 650° C. or 980° C., weld metal was more resistant to attack than plate metal.

Electroplating Practice in Germany

Full and Semi-Automatic Plants

FULL-AUTOMATIC plating plants are operated in Germany by the large motor-car works and other factories, chiefly for depositing nickel, copper and chromium. Considerable success has also been obtained with full-automatic silver plating of hollow ware. The principal features of these plants are very similar to those in England and in the United States, but German automatic plating plants differ largely in regard to output and design owing to the specific requirements of the German industry stated Mr. Richard Springer, of Langbein-Pfanhauser-Werke, A.G., Leipzig, in a paper read at the recent International Electrodeposition Conference, organised by the Electrodepositors' Technical Society in London.

It is understood that full-automatic plating plants embody all well-known modern features such as safety devices and automatic temperature and pH control. For completeness, there is the so-called station-type plating automatic which is particularly suitable for short deposition periods such as for de-scaling by the Bullard-Dunn method for which, it is understood, it has been designed in the United States. The equipment consists chiefly of a large spoke wheel with rotating, lifting and lowering device mounted in the centre of the circle. The plating racks are attached to the wheel which, after each lifting motion, revolves so far around its axle as is necessary to transport the racks from one vat into the other. The various vats for cleaning, swilling and plating are arranged in a corresponding circle. This design has been used in Germany for tin plating.

[Preference for Semi-Automatic Plants

The existence of a comparatively large number of medium-sized factories in Germany accounts for the preference of semi-automatic plating plants, such as travelling chain vats and circular vats with rotating cathode ring. It is estimated that about 300 semi-automatic vats have been installed in Germany during the last year, for depositing nickel, chromium, copper, brass, cadmium and silver.

Small articles such as bolts, nuts, rings and similar goods are plated in full-automatic barrel plants transporting the articles from one barrel to the other by the well-known worm-gear method. A new feature is the ingenious invention of the so-called reversion step, by which the goods in the plating barrel are transported two steps forward and one step backward. The object is to avoid building very long plating barrels and to be able to change the plating period without altering the speed of the other transport features of the plant.

Great success has been achieved in Germany with full-automatic chromium barrel plating, a problem which presented considerable difficulties. This automatic consists of a barrel with eccentric inside anode and worm-gear. The articles to be plated are automatically fed to the barrel from a bunker and discharged after about 10 minutes with a brilliant chromium deposit. The output is 30 to 75 lb. per hour depending on shape and size of the articles. In one instance, one of these automatics has replaced 12 operators by doing away with racking.

Bright Nickel Plating

A survey of automatic plating in Germany would not be complete without mentioning electrolytic wire galvanising, in which field the German electroplating industry has been leading for many years. About 60 large plants with a total consumption of about 300,000 amperes are now in operation in Germany and abroad. A large Canadian steel company has recently acquired an exclusive licence for the process for Canada.

Recent years have brought considerable progress in bright nickel plating in Germany. Two German bright nickel solu-

tions—that introduced by Dr. Schlötter and the "mirror gloss bath" of the Langbein-Pfanhauser-Werke—have given highly satisfactory results. While the Schlötter process has been used chiefly abroad, the plants in Germany mainly use the LPW process.

One of the largest manufacturers of motor car wheel caps in Germany works as follows: The polished brass caps are first degreased in trichlorethylene and subsequent thereto in a proprietary cleaner, then slightly brushed with Sheffield lime pap, rinsed, acid-dipped, rinsed again and nickel plated for 30 minutes in a bright plating solution at a current density of 1.3 amp/sq. dm. (12 amp/sq. ft.). The nickel plating process is immediately followed by 5 minutes' chromium plating. The process described is very reliable and rejects are less than 0.5 per cent. The fact that the bright nickel plating process is not only suitable for small, but also for large articles, is evident from the introduction of this process for nickel plating bumpers in one of the largest motor car factories in Germany. The steel bumpers are first heavily copper plated and then polished. It has been observed that parts such as bumpers should be electrocleaned with simultaneous coppering, as otherwise the adhesion of the bright nickel deposit to the copper layer is affected adversely. It is, however, necessary that this degreasing bath works faultlessly as otherwise the articles become dull, which affects the bright nickel plating.

Bright nickel plating effects savings not only on polishers' wages and polishing material, but also on nickel. According to the standard specifications recently issued by the Master Electro-Platers Institute in co-operation with the American Electro-Platers Society and the United States Bureau of Standards, buffing takes away at least 10 per cent. of the nickel deposit, which is sheer waste. The nickel deposit on the edges is weakened even more, and the corrosion resistance diminishes accordingly.

Nickel Anodes

It would appear from a recent issue of the Metal Industry, London, that Germany has no nickel at all. This assumption is not quite correct as far as the plating industry is concerned. A shortage exists in metallic nickel, for instance nickel anodes, but there is a sufficient supply of nickel sulphate of German manufacture available. German platers have adjusted themselves to this condition by working their nickel solutions with insoluble anodes, replenishing the metal and adjusting the acidity by the addition of nickel carbonate. Out of this practice developed the improved method of re-nickelling nickel anodes in separate vats. Nickel is deposited on lead strips in the manner just described and these strips are then used as anodes in normal nickel vats. In other words, the platers manufacture their nickel anodes in their own works.

The German high efficiency tinning baths are characterised by the fact that they are built up on aromatic sulphonic acids and their salts and allow the production of bright deposits also at high current densities. It must, however, be admitted that, in spite of some contrary statements, the problem of bright tin plating has not yet been entirely solved and that there is no tinning bath producing absolutely bright deposits. Tinplate is being produced in Germany by electrolytic processes, but the resulting brilliance is only obtained by a subsequent treatment of the plate, mostly by subsequent rolling, 90 per cent. of all cadmium baths are now producing bright deposits. The German bright cadmium solutions compare well in every respect with the bright cadmium solutions used in other countries. A considerable amount of cadmium plating is done in barrels.

Electroplating of aluminium has gained special importance

in Germany particularly in recent years. Until some years ago, the success of the nickel and chromium plating of aluminium was more or less accidental. This question has been studied more closely in the last two years, and it can be said that it is now possible in Germany to nickel and chromium plate almost every aluminium alloy. Before electroplating, the aluminium or aluminium alloy is subjected to a preliminary dipping treatment in which a very thin film of a nobler metal, for instance zinc, is deposited on the base metal. The article thus treated is then cyanide-copper plated for about 10-20 minutes and is then ready for any further treatment. The treatment known as the Ballay process, consisting of dipping in an iron dip, has been partly abandoned in Germany.

By a further and somewhat complicated process, aluminium is first anodically oxidised, the anodic film is then wholly or partially removed and the article is then plated in the usual manner. As is known, brass in Germany has already been largely superseded by aluminium and this development is encouraged by the raw material situation.

Anodic Oxidation of Aluminium

Aluminium has now become one of the most important raw materials in Germany. Its protection by anodic oxidation is therefore a question of special importance. There are at least 200 anodic oxidation and colouring plants, some of them of considerable size, in operation at present and the number is increasing constantly. These plants anodise aluminium and aluminium alloys partly for technical and partly for decorative purposes. Anodic films give excellent surface protection against corrosion and mechanical wear. They can be dyed in practically any colour and it is apparent that this process has helped greatly in substituting aluminium for copper, brass and nickel, of which metals there is a shortage in Germany.

It is particularly gratifying to emphasise the fact that the considerable progress which has been made in the field of anodising aluminium during the last 3 years is due to international co-operation by the establishment of a working agreement between German and foreign interests. Exchange of patent rights has cleared a very complicated patent situation and exchange of experience has given a powerful impulse to further technical progress. The group comprises the Eloxal, the Alumilite and the well-known Bengough processes.

Importance of pH in Alkaline Baths

The importance of the pH of alkaline electroplating solutions has been reported recently in Germany, Britain and America. The importance of pH determination in acid electroplating solutions is generally known and accepted. It is however peculiar that the influence of pH value in alkaline baths has hardly been studied. The results of the researches are briefly as follows:—(a) Brass baths work best within the pH range of 9.5–10.2; over pH 10.2 the deposits are discoloured which, as will be shown later, is probably due to the formation of zincate. (b) The degree of adhesion of cadmium deposits is sometimes not as it should be; by increasing the pH value to 12.0, or more, it is possible to obtain well adherent deposits. (c) In copper baths with high contents of potassium cyanide, the formation of blisters can be reduced by increasing the pH.

A new test paper is quickly replacing other methods of pH determination. It combines the simple handling of litmus paper with the exactitude of the colorimetric pH testers. The test paper strip consists of a special quality filter paper, impregnated with 7 cross stripes of different colours. A wide strip in the centre is the indicator and 6 small stripes represent an unalterable comparator scale. The stripes of the comparator scale are of different colours, each colour corresponding to the "turning colour" of the indicator at the pH number marked at the side. The pH number of a plating solution is measured in a few seconds by immersing the strip in the solution, comparing the altered indicator colour with the comparator scale and reading off the pH number.

The advantage of this test paper as against other colorimetric measuring methods are in short as follows:—(1) The colour of the plating solutions, which varies considerably, is balanced without a special comparator. (2) The pH paper, owing to the kind of packing used, is protected against the influence of light and, therefore, remains intact almost indefinitely. (3) Any special implements such as glasses, comparator tubes and colours, folios, indicator solution, etc., are dispensed with. (4) The paper can be gauged for special purposes.

The last mentioned point is important for a definite reason. All colorimetric measuring devices are gauged by means of buffer solutions. It can be observed quite frequently, however, that nickel solutions give values which are too high or, sometimes, too low compared with those obtained by electro-metric methods. The value obtained is influenced not only by the salt error and the buffering of the solution, but exact tests have shown that even the metal itself alters the value in a certain direction. For this influence, hitherto not yet described, it is proposed to use the term "metal error." With the special test paper described above, it is possible to gauge the measuring scale with solutions electrometrically adjusted to a special use, for instance for nickel solutions, zinc solutions, etc. In this way salt errors and "metal errors," which hitherto have played an important part in the colorimetric measuring method, can be eliminated. By using indicators hitherto unknown it has been possible to cut out the dichroism of the bromcresol-purple indicator. In order to obtain exact pH values which can be compared with each other it is necessary to measure at room temperature, as is more or less required with all pH methods.

Analytical Progress

An improved method of analysing brass solutions can be reported here for the first time. The electro-analytic or gravimetric methods being too complicated for practical purposes, a method was desired which would permit the easy determination of the various components of brass baths. The determination of copper by the usual iodide method presents no difficulties. More difficult is the determination of the zinc content, as the titration of zinc is disturbed by copper. It has been found that after boiling and evaporating a quantity of the brass solution with sulphuric acid, the copper can be precipitated quantitatively by adding a 25 per cent. solution of sodium thiosulphate and by subsequent boiling. In this solution which needs no filtration, the zinc can be titrated with a solution of potassium ferrocyanide, the end point being ascertained by spotting on uranyl acetate paper. This method is very simple and ensures a reliable determination of zinc.

In 1932, Pan described in "Metal Industry" (New York) a method for the determination of free potassium cyanide in brass solutions. This method was tested and found correct only if the pH value of the solution lies between 9.8 and 10.0. At higher pH values, this method gives a higher content of free potassium cyanide, which leads to the conclusion that the potassium cyanide is freed at higher pH values owing to the formation of zincate. This observation agrees with the results of pH experiments in brass solutions, which revealed the fact that brass solutions having a pH value of more than 10.2 work of considerable importance in multi-colour printing.

Bullard-Dunn Descaling Process

The American Bullard-Dunn process for electrolytically descaling hardened steel has been introduced in Germany during recent years with great success. Up to about two years ago, only one German firm used this process, but there are now about 20 large firms of the motor car, aeroplane engine and metal industry using the Bullard-Dunn method. The chief advantage is that there is no attack on the base metal and no embrittlement due to excessive hydrogen penetration. The measurements of calibrated parts are not altered and it is stated by a large German motor car manufacturer that gears cleaned by the Bullard-Dunn process run more smoothly than when descaled by other methods. Many more firms are

contemplating replacing sand-blasting by the Bullard-Dunn process, which has now also been adopted by a large British motor car factory.

The shortage of non-ferrous metals in Germany has led to the extended use of bakelite, celluloid and similar materials instead of metal in the manufacture of numerous articles, such as door handles and fittings, lighting fixtures, ash trays, cigarette cases, etc. This has opened a new field of activity for the plating industry by plating non-metallic surfaces. A new and improved process has been developed which ensures perfect adhesion of the metal deposits. Plating costs are practically the same as they are for plating on metal, as the pressed articles need no polishing before plating. The plated articles are hardly distinguishable in appearance from solid metal.

Hard Chromium Plating

Hard chromium plating is playing an important rôle in Germany and affecting considerable savings on gauges, tools, bearings, drawing plates, dies, pressing moulds, printing plates and cylinders and similar parts requiring resistance against mechanical wear. The usual current densities of about 50–80 amp. per sq. dm. (470–750 amp./sq. ft.) are employed and deposits can be obtained up to practically any desired thickness without peeling or brittleness. There are probably no features connected with hard chromium plating in Germany which are essentially different from practice in other countries.

As will be seen from the foregoing, the German electroplater has to work to-day under somewhat different conditions than his colleagues in other countries owing to the present German raw material situation. Nevertheless, as now problems mean new progress it is hoped that the German electroplating industry will in the future as in the past be able to contribute its share to further technical and scientific advancement in the art of electro-plating.

Electroplating in the Printing Trade

Electroplating is also very extensively used in the German printing trade. Aside from the well-known electrotyping processes in which semi-automatic circular vats are employed for large outputs and for making copper electros in two hours, chromium facing is used for printing plates and intaglio printing rollers.

For copper depositing intaglio cylinders a patented process is used with considerable success. The object is to deposit a copper skin in a thickness sufficient for one etching only and stripping this skin off the base after etching and printing. This comparatively thin copper deposit leaves the bath so smooth that the hitherto necessary grinding, a costly operation, is eliminated and short treatment only is necessary to make the cylinder ready for etching. The chief advantages are elimination of grinding, therefore no waste of copper and the constant circumference of the cylinder, which is of considerable importance to the printer, especially in multi-colour printing.

The Flow of Metals

Annual May Lecture of the Institute of Metals

PROFESSOR E. N. DA C. ANDRADE, D.Sc., Ph.D., F.R.S., delivered the 27th annual May lecture before the Institute of Metals on May 5, in the hall of the Institution of Mechanical Engineers, London. Mr. W. R. Barclay, president of the Institute of Metals, was in the chair.

Flow is most easily observed in the liquid state, but whereas there is a satisfactory theory of gases, and the structure of crystalline solids has been elucidated by the methods of X-ray analysis, very little is known of the actual behaviour of the molecules in the liquid state. It lacks the regularity of the crystal, and the molecules are too close to show the simplicity of behaviour that characterises gases. A liquid has about the same density as a solid, and can be regarded as a solid in which the heat agitation leads to a slow movement of the molecules from their places, a molecule travelling through a distance equal to its diameter after something less than, but approaching a hundred impacts.

The lecturer has actually put forward a theory of liquid viscosity on the basis that the momentum is transmitted from layer to layer not, as in a gas, by the passage of molecules from one layer into the other, but by instantaneous association of the molecules when they touch, so that at any nearest approach two molecules share their momentum. On this basis a formula can be derived which gives the viscosity of a simple liquid at its melting point, and another which gives the temperature variation of the viscosity.

Molten metals are particularly suitable for experiments designed to throw light on this problem of viscosity, because they constitute liquids which consist of one kind of atom only, and they are not, in general, associated. The viscosity is conveniently measured by sealing up the molten metal in a sphere, suspended in vacuo, and observing the damping of the torsional oscillations of the sphere about a vertical axis due to the enclosed liquid. The method has already been used for the alkali metals, and is being extended to other metals.

The flow of solids is, perhaps, at first sight, even more troublesome theoretically than the flow of liquids, for single

crystals of metals exhibit plastic flow under very small stresses, whereas a perfect crystal should firstly be strong, and secondly be brittle. Again, single crystals of metals show a very marked hardening with flow. The mechanical properties of metal crystals have been elucidated by the work of Polanyi, Schmid, G. I. Taylor and others, and it is now known that the factor which initiates plastic flow is the shear stress in a certain crystal plane and in a certain crystal direction, which can be found by experiment, but there is no general rule, applicable to all crystals, which enables us to decide beforehand what the plane will be, whereas the direction is always the direction in which the atoms are packed most closely. The glide direction seems to be more significant and fundamental than the glide plane.

Internal Flaws in Crystals

To explain how it is that metal crystals can flow at all various workers have suggested, with different detail, that, in the ordinary crystal, places exist where the atoms are out of step, for a small distance, with their immediate neighbours, such regions being called "dislocations" by Taylor. It can be shown that quite a small shear stress will cause such a dislocation to run along, leaving the atoms in the region through which it passes advanced by one. The weakness and the flow of single crystals is explained along these lines. Other internal flaws have been involved to explain the time factor in the flow, and the hardening. It cannot be said that there is any fully satisfactory theory of the flow of single crystals of metals, but a good beginning has been made.

It is, of course, a far step from the single metal crystal to the polycrystalline metal of industry, but we can see that any crystal boundary is likely to stop the propagation of a dislocation, or glide in general, and so will make the metal less weak and less liable to flow. Industry cannot, of course, wait for theory, but the only really satisfactory way to approach the problem of the strength of metals is by way of the single crystal.

Some Recent Metallurgical Patents

Extracting Precious Metals

Precious metals are recovered from ores by extraction with dilute alkaline cyanide solution, subjecting the solution to a conditioning operation which renders the solution capable of actively reacting with a metallic precipitant, deoxidizes the solution, and neutralises alkalinity to an extent sufficient to afford a pH value of from 6–8.4, and then contacting the solution with a metallic precipitant such as zinc or iron. The conditioning operation may comprise the addition of sodium or calcium bisulphite, sulphur or carbon dioxides, either singly or in combination, a suitable source of mixed dioxides being flue-gas. Before the addition of bisulphite, the solution may be neutralised with sulphuric acid and the bisulphite may be formed by interaction between the alkali or alkaline earth ion in the solution and sulphurous acid. (See Specification 451,979 of Merrill Co., Mills, L. D., Crowe, T. B., and Haun, J. C.).

Steel Degasifying Alloy

An alloy for use in degasifying and purifying molten steel consists of iron with 15–25 per cent. of titanium, 1.5–5 per cent. of carbon, up to 3.5 per cent. of silicon, and up to 3 per cent. of aluminium, the carbon content being less than one quarter of the titanium content. The alloy may be made in a carbon-lined electric furnace having an inner lining of a titanium compound formed by melting in the furnace a charge containing a titanium ore and carbon, such ore, for example ilmenite, being in excess of that required to produce a completely fusible mass. Subsequent charges for the production of the required alloy contain also steel scrap. (See Specification 452,092 of Titanium Alloy Manufacturing Co.).

Heat-Treating Magnesium Alloys

Magnesium alloys susceptible to precipitation hardening are homogenised by first heating the alloys to temperatures which are below the melting point of the metastable constituent, but are sufficiently high to induce homogenisation, until the bulk of the heterogeneous constituents surrounding the primary crystals have been dissolved in the latter and then heating the alloys at or above the melting point of the metastable constituent but below the temperature of incipient fusion until the solution of the heterogeneous constituents in the primary crystals has been completed. The first heating may be caused to merge into the second heating by gradually increasing the temperature of the first heating, the merging taking place only when the bulk of the heterogeneous constituents have already dissolved. The alloys which are susceptible to precipitation hardening are binary alloys containing aluminium, zinc, lead, tin or bismuth or multiple alloys containing two or more of such elements, the magnesium content of all such alloys being not below 80 per cent. Other elements incapable of causing precipitation hardening such as silicon and manganese may be present in amounts up to 2 per cent. In the treatment of alloys containing 3–12 per cent. of aluminium, the first heating is carried out at temperatures below 436° C. and the second heating at or above 436° C. In an example, an alloy containing 8 per cent. of aluminium and 0.3 of manganese was first heated for 5 hours at 420° C. in an electric furnace containing an atmosphere of carbon dioxide, and the temperature was then raised to 436° C. and maintained thereat for 16 hours. The alloy may then be annealed for 16 hours at 150° C. to improve further its mechanical properties. (See Specification 452,390 of I. G. Farbenindustrie).

Annealing

The magnetic properties of iron silicon alloys are improved by subjecting the alloys to substantial deformation, *e.g.* to the extent of at least 40 per cent., in the cold or at a relatively low temperature and then annealing for a period of hours, *e.g.* from 4–100 hours, at 1,000–1,300° C., in a protecting gas such as pure hydrogen. The alloys usually contain 0.5–5.0 per cent. of silicon, but with higher silicon contents the de-

formation may be effected at an elevated temperature, *e.g.* 100° C. Intermediate annealing, *e.g.* at 800° C. for $\frac{1}{2}$ hour may be employed if the cold working takes place in steps. When the alloys are used in strip or bar form for the manufacture of ring cores, the strips, etc., after the deformation may be built into rings of the desired shape to prevent sticking, separated by thin layers of clay, lime, etc. The rings so produced are then annealed. (See Specification 452,497 of Krupp Akt.-Ges., F.).

Distilling Zinc

In a process for recovering zinc and other volatile metals from oxide ores and the like by reduction with carbon monoxide, the products of the reduction are passed through carbonaceous material heated to about 1,000–1,100° C. and the resulting carbon monoxide is returned to the reducing chamber with or without the addition of further gaseous fuel. The gases from the carbon chamber are cooled to about 800° C. for the deposition of any sublimed lead and sulphides before being passed to a condenser for the deposition of the zinc, etc., and thence to the reducing chamber. The solid residues together with the deposited lead and sulphides are removed from the carbon chamber and replaced. The charge of ore, etc., may contain also some carbonaceous material, or loosening material such as lumps of chamotte or coke. Some of the carbon monoxide obtained by the treatment of the carbon dioxide may be used for heating one or other of the chambers, and the waste gases may be used for drying or preheating the charge. (See Specification 452,645 of Lebedenko, N., and Elian, J.).

Alloys

An alloy containing a major proportion of one or more metals having an affinity for nitrogen, or the components of such an alloy is or are intimately mixed with sufficient of a nitrogen containing oxidising agent and of a reducing agent to melt the alloy by the heat of reaction between the oxidising and reducing agents, such reaction being caused to take place in the absence of substantial amounts of reducible metal oxides, nitrogen liberated by the reaction being thus brought into contact with and incorporated in the molten alloy. Ammonium, sodium, potassium, and calcium nitrates may be used as oxidising agents as also may nitrites; the reducing agent may be aluminium or silicon. Ferrochromium, high in silicon, may be mixed with sodium nitrate and lime and the charge ignited by means of magnesium powder, to produce an alloy comprising iron, chromium, carbon, silicon, and nitrogen. In addition to ferrochromium, any alloys comprising a major proportion of titanium, zirconium, cerium, vanadium, niobium, tantalum, chromium, molybdenum, or tungsten, may be treated. (See Specification 456,465 of Electro Metallurgical Co.).

Tin Statistical Year Book

THE International Tin Research and Development Council has published in English a Statistical Year Book containing a complete and up-to-date record of statistics relating to tin. This book should prove valuable to industrialists and manufacturers in all countries, as well as to the numerous investors in industries in which tin plays a part. The book deals exhaustively with the tin producing and consuming industries, giving where possible, the quantities of tin used in individual industries in each country; the sources from which each country obtains its supplies of tin; and details of the trade in tin and in manufactured articles containing tin. It is illustrated throughout by charts which enable the reader to appreciate the significance of the statistics at a glance. Notes are included indicating the methods by which the statistics have been compiled. Copies may be obtained from the International Tin Research and Development Council, price 6s. post free to any part of the world.

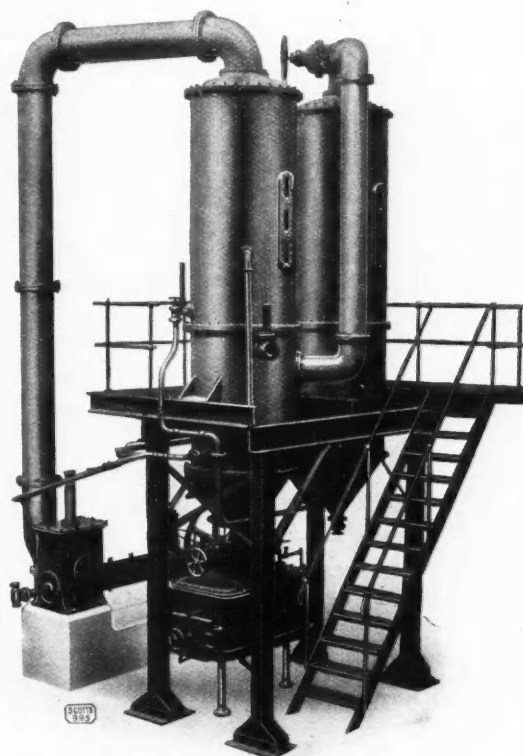
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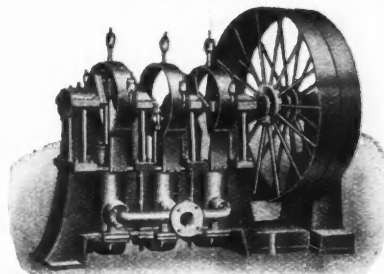
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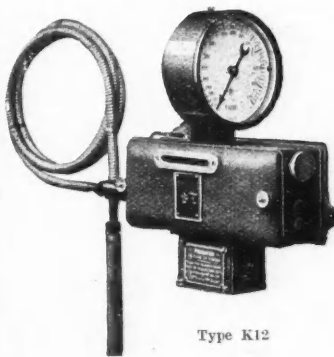
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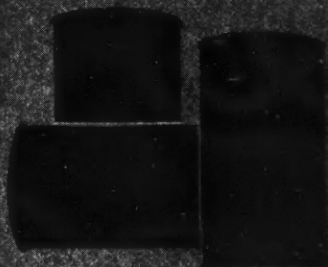
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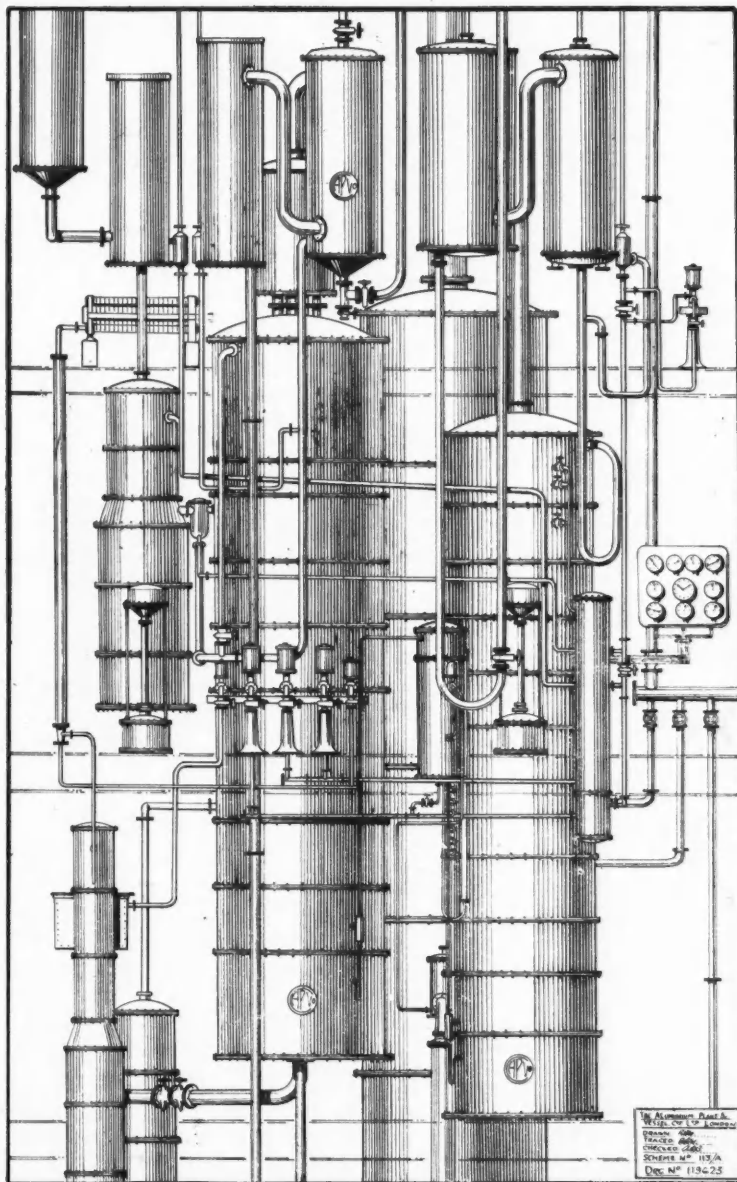
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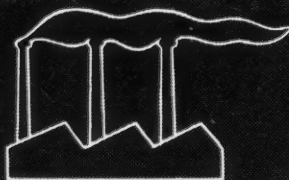
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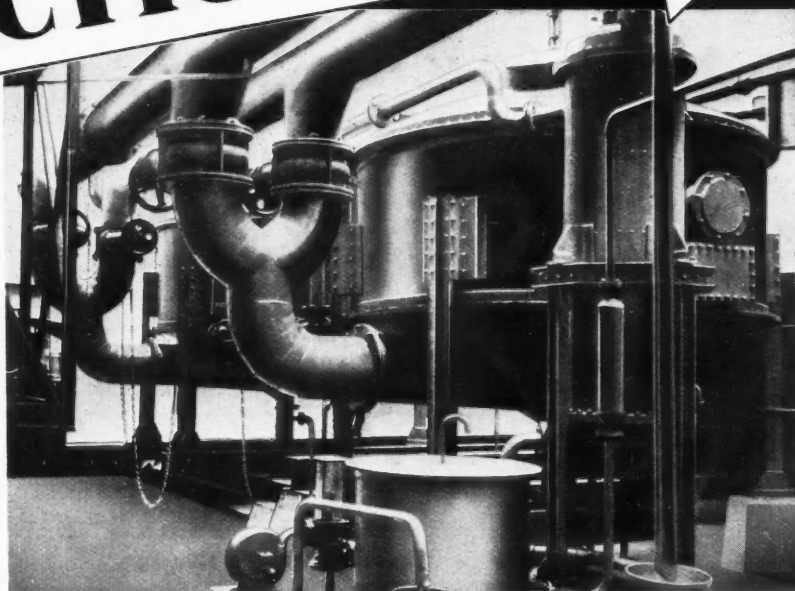
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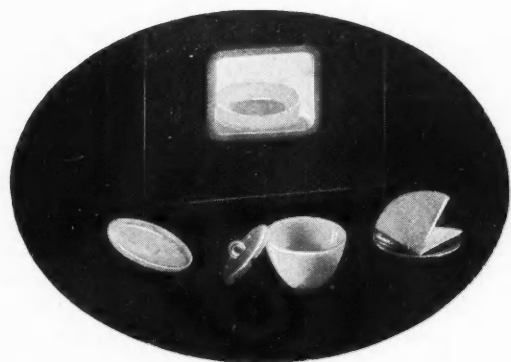
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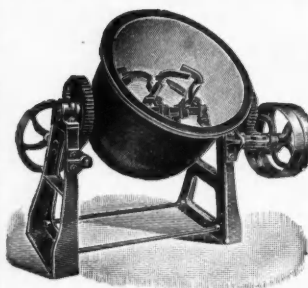
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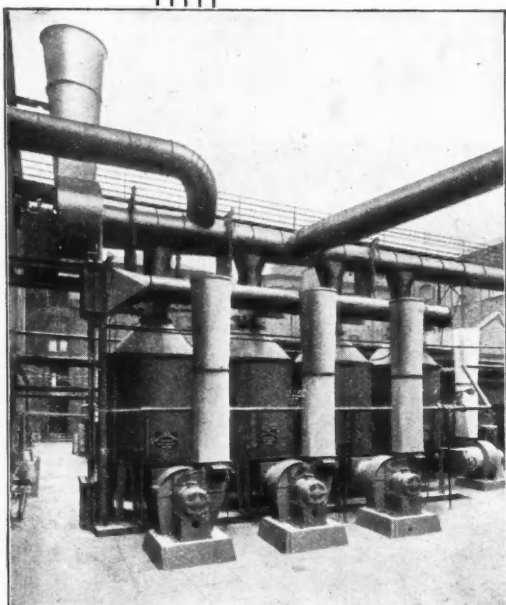
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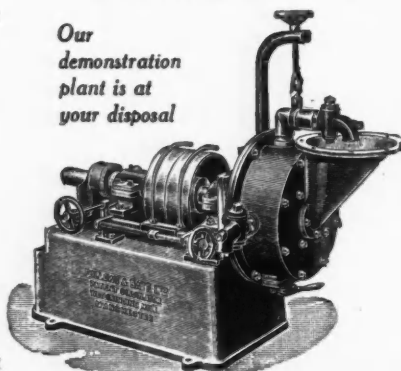
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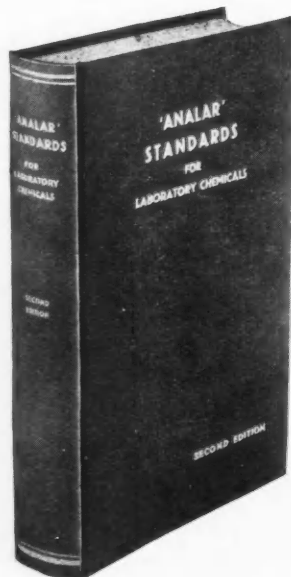
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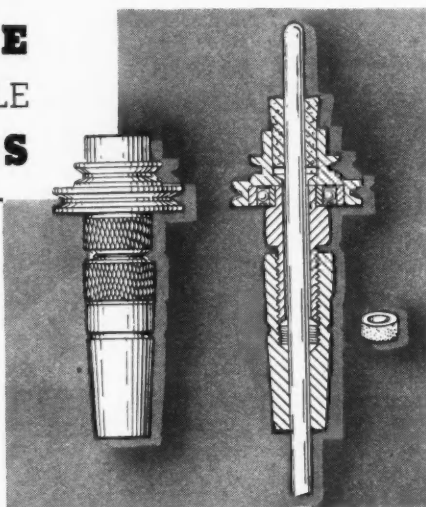
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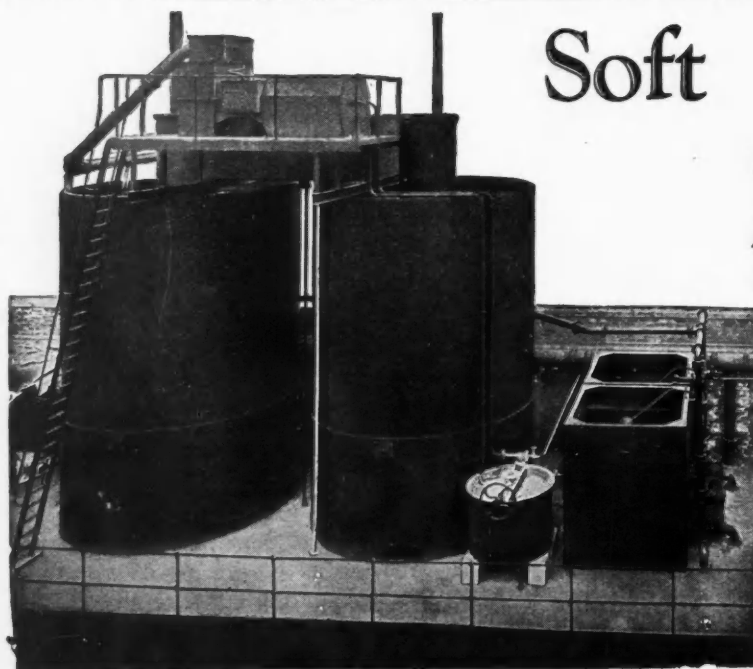
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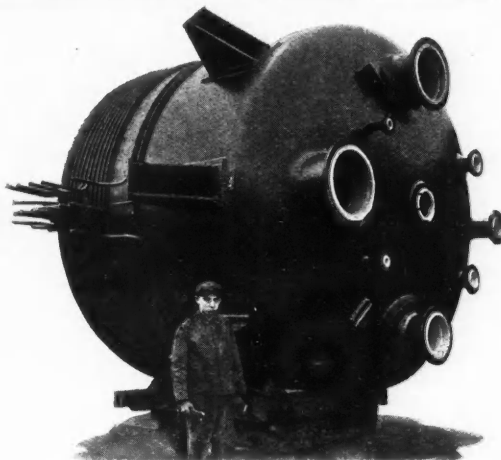
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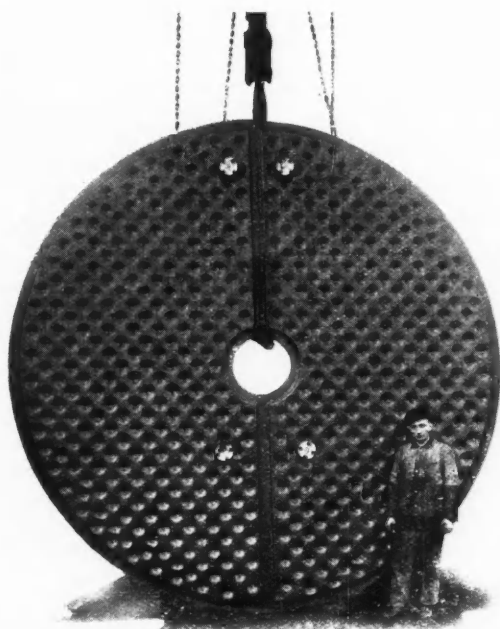
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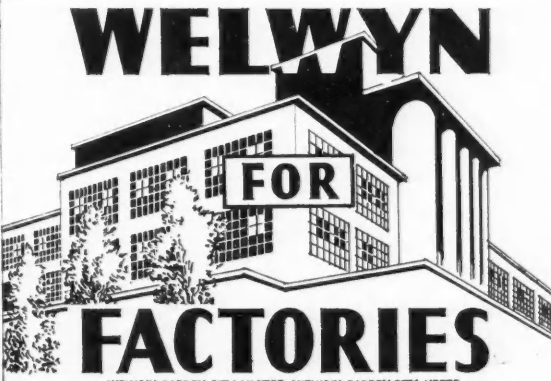
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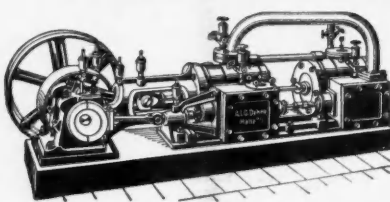
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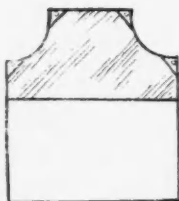
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